ESPON 2006 PROGRAMME

ANSWER TO THE TENDER ESPON 3.4.3

THE MODIFIABLE AREAS UNIT PROBLEM

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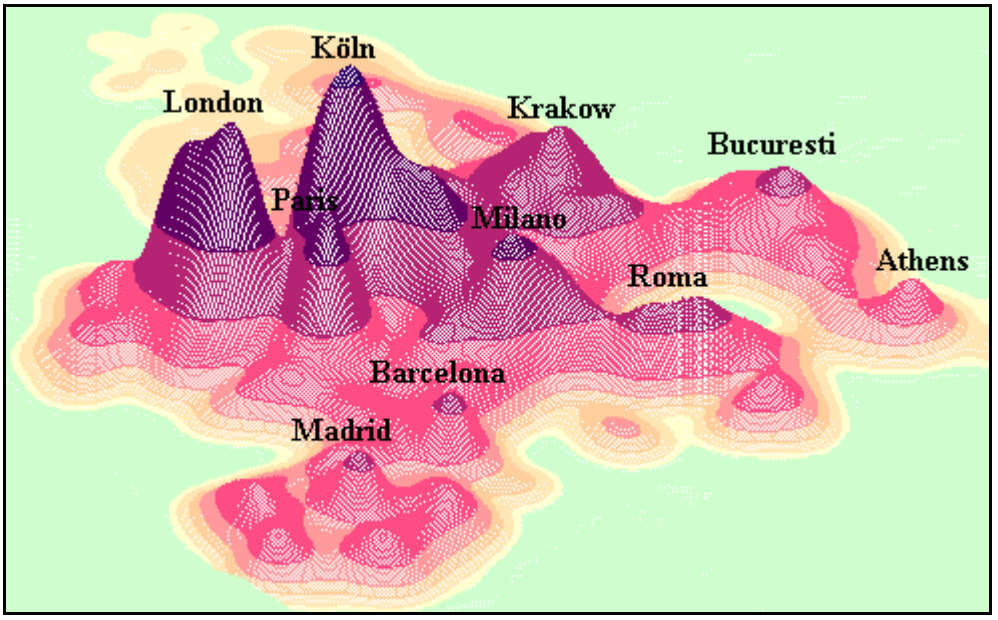

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1 MAIN OBJECTIVES

1.1 Analysis of Terms of Reference

In this first section, we briefly present and comment on the T.O.R. of the project ESPON 3.4.3 (MAUP) in order to extract the main important features to be developed in the next section.

1.1.1 General objective

According to the Terms of Reference published on the ESPON website, the general objectives of the project 3.4.3 are the following ones

Currently all ESPON project are asked to carry out their spatial analysis at NUTS 3 level. However, first results have raised the question as to whether this is the most appropriate approach for spatial analysis. Indeed, it is sometimes impossible to find a proper mixture of analytical units which insure the comparability of territorial division in different countries.

The Modifiable Areas Unit Problem (MAUP) has been recognised since the 1970s. The cartographical pattern of spatial distribution of variables or the level of correlation between two variables distributed in space can be completely modified according to the level of aggregation of spatial units or more generally the spatial grid used for collecting and presenting spatial information. The MAUP has very deep consequences, form theoretical, methodological and practical points of view and is a major challenge when using spatial information for statistical or cartographical purposes.

This has also been experienced within the SPESP (Study Programme on European Spatial Planning) and the ESPON. In both the work with NUTS 3 and 2 levels has been criticised by many researchers who prefer to use a combination of NUTS 2 and 3 levels in order to achieve a better homogeneity of surfaces and population or even approach not at all related to NUTS. In addition also other possibilities related to functional regions, travel to work areas etc. have been considered at various occasions.

Indeed, within the work of spatial integration (action 1.4) under the SPESP and the ESPON 3.1 (and also 1.2.1) project, different solutions for the delineation of areas have been discussed.

In order to assess MAUP and the implications of possible solutions for future ESPON research, it has been decided to launch an ESPON support study on this issue. This study shall investigate possible solutions and their implications on research findings, policy recommendations and the dialogue with practitioners in further detailed. Here, one needs to keep in mind that a proposed methodology needs to serve both the purpose of spatial analysis and application through existing institutional settings. Furthermore, it needs to focus on the specificities of the geographical area to be covered by the research, which is EU25 plus Bulgaria, Romania, Norway and Switzerland.

The aim of the study is thus to provide input for improving the spatial analysis in current ESPON studies and future research in the field. With regard to this, the key issue for the study is the assessment of the possible policy acceptance of an improved spatial analysis. ESPON maps are an important element in the dialogue with policy-makers at European and national level and within various sectors addressed by ESPON. Therefore it is important that the format in which ESPON maps are presented is understood and accepted by these policy-makers.

The terms of reference clearly explains that MAUP is not a classical ESPON Project but a **Scientific Support Project** which means that very precise outputs are expected in order to improve past and future production of research developed in the ESPON Program (especially considering the future ESPON II). It is also clearly indicated that the MAUP problem has not been ignored in previous work of ESPON. This question has been identified in several projects working in the field of **Spatial Analysis and Cartography**. For example, in the

framework of the SPESP, where C. Grasland had proposed a working paper called "Objective 13 bis" which suggests that the allocation of funds to regions could be strongly modified by the choice of various territorial breakdowns. The problem to be analysed is scientific AND political and both aspects should be jointly covered by the answer: a solution which would be acceptable from a scientific point of view could be unacceptable from a political point of view. **It is therefore necessary to combine both dimensions (scientific and political) in the answer**.

1.1.2 Primary research questions

The terms of reference propose primary research questions as guidelines for the answer to be elaborated :

1) Different approaches for overcoming the MAUP challenge
The first step of the study will be to identify and present different solutions for overcoming MAUP. This should include the mixing of NUTS 2 and NUTS 3 levels as well as other possible approaches such as the use of functional areas, local labour market areas, grid net data and/or localised information (e.g. residences or places of work). Each approach needs to be described and analysed according to its possibilities and limits (advantages and disadvantages) for achieving a better comparability between countries constituting the ESPON space.

2) New map collection
Following the approaches identified, 10 to 15 existing ESPON maps are to be reworked for each of the viable alternatives identified in the first step of the project. The selection of maps is to be made in co-operation with the ESPON Coordination Unit. Special attention has to be paid to maps which are important means for communication with other policy sectors. Accordingly, maps on transportation/accessibility, ICT, R&D and CAP need to be part of the new map collection.

3) Implications on findings and policy messages
Having produced a new map collection, the various approaches to overcoming MAUP need to be assessed regarding their implications on (a) research findings and (b) policy messages deriving from the new maps. A thorough assessment of the differences in findings and policy messages derived from the various approaches needs to be provided. This implies an interpretation of the "old" and "new" maps and the differences between them.

4) Assessment of implications for policy dialogue and acceptance
An important part of the study is the assessment of the acceptance of maps based on approaches overcoming MAUP. The main challenge of ESPON is to communicate research findings to practitioners and policy- makers in various sectors. Thus the implications of policy dialogues and the acceptance of new types of maps need to be tested and assessed. For this a series of maps from the new map collection are to be selected in co-operation with the ESPON CU and tested according to their readability and acceptance by policy- makers in various policy fields. The policy fields to be covered include regional policy, transportation policy, telecommunication policy, research and development policy, common agricultural policy. The focus will be on European level policy makers but to a certain extent also national policy makers are to be included. This assessment of acceptance needs to be carefully planned and documented and concluded by a comprehensive assessment leading to recommendations on the approach to be used in future ESPON projects.

5) Resume on the methodologies and recommendations for future ESPON projects
Finally, the various steps of the study need to be summed up in a resume on the MAUP problem, possible solutions and their implications. Summing up the main advantages and disadvantages and the limits of the new methodology recommendations for future ESPON project are to be elaborated. The study team should seek contact and co-operation with other relevant actors in the field, such as Eurostat, EEA, JRC and the INSPIRE programme.

Points of departure for the project are the work developed under the action 1.4 – spatial integration of the SPESP and the ESPON project 3.1.

These guidelines give a confirmation of our previous analysis concerning the fact that our answer to the MAUP should necessarily combine **scientific innovation and political validation**.

- Primary research question (1) indicates clearly that *an in-depth scientific approach of the MAUP problem is requested*, which should focus on the question of NUTS2/NUTS3 but should also examine the general dimension of the problem, whatever the level of territorial aggregation. The T.O.R. indicates indeed that the solutions should be applicable to other types of data including flows or local statistics. Therefore, we propose to build a specific workpackage on the general evaluation of the MAUP problem on a particular territory where all the dimensions of the problem of aggregation can be jointly analysed. Such in-depth analysis can not be produced on all European state but is necessary in order to avoid particular solutions to the general problem. Therefore, we proposed a two-step analysis where all scientific tools will be firstly analysed on a limited area where maximum information is available (Sweden) and then applied to the whole ESPON area.
- Primary research questions (2) indicates that *the consequences of MAUP on cartography* are a major topic. It is true that MAUP has also important consequences on statistical analysis (e.g. results of cluster or correlation analysis are strongly modified by changes in territorial units) but the T.o.R. suggests concentrating the research on the consequences for cartography, because it is the tool which has the major impact on political decision. This priority on cartographic consequences of MAUP rather on statistical consequence is questionable because both types of analysis are strongly related. But we will respect the suggestion of the T.o.R. and focus our analysis of cartography and simply indicate short examples of statistical consequences of the MAUP.
- The primary research questions (3) and (4) are strongly inter-related and, in our opinion, should be analysed in a common workpackage. For a limited set of topics (proposed by the CU) we will realise a *collection of classical and innovative representations and explain the different messages that are transmitted by the various maps*. It is on the basis of this collection of maps that the Coordination Unit and the Monitoring Committee will be invited to discuss the political acceptance of the various possible solutions. To make this comparison of various solutions more efficient, we will develop several communication/evaluation tools, not necessary based on paper format. We propose to use hypertext presentations (on web or CD-ROM) coupled in some cases with specific software (animated and interactive maps). Indeed, we strongly believe that the problem to be solved is not necessary to produce THE BEST map of a phenomena but ADAPTATIVE COLLECTIONS OF MAPS of the target phenomena which can be modified interactively according to users' needs.
- The primary research question (5) indicates clearly that the solutions which will be proposed should not only be efficient but also simple and easy to use for future members of the ESPON program. Too sophisticated methods should therefore be avoided if they can not be easily adopted by members of the ESPON community. To fulfil this requirement, we will introduce in our final report a dictionary of tools which will explain the "know-how" and propose precise examples in a didactic way. Contacts with European statistical agencies (EUROSTAT, EEA) will insure feedbacks on the usefulness of these tools and their connexion with existing databases.

1.1.3 Expected results and timetable

The expected results and timetable proposed by the T.o.R are the following ones

> *The study is expected to provide assistance for improvements of the comparability of NUTS analysis between different countries. The recommendations of the study are to inspire current ESPON projects regarding their spatial analysis and lay the ground for improved analysis in future research. This calls for a timing of reporting deadlines and expected results in accordance with the timetable below.*
>
> ***September 2005: Interim Report***
> *(a) Presentation and analysis of the MAUP problems and possible approaches to overcoming it (cf. step 1 primary research issues envisaged).*
> *(b) New map collection elaborated by using possible approaches for overcoming MAUP (cf. step 2 primary research issues envisaged).*
> *(c) Assessment of implications on findings and policy recommendations deriving from the new map collection (cf. step 3 primary research issues envisaged).*
> *(d) Presentation of a detailed proposal for assessing the implications for policy dialogues and acceptance of maps from the new map collection (cf. step 4 primary research issues envisaged).*
>
> ***January 2006: Final***
> *Deepening of elements provided in the first Interim report, and new key elements:*
> *(e) Assessment of the implications of alternative mapping approaches for policy dialogues and acceptance of such maps by policy-makers in various sectors (cf. step 4 primary research issues envisaged).*
> *(f) Resume on the methodology and recommendations for future ESPON projects (cf. step 5 primary research issues envisaged).*

- The timing proposed in the T.o.R is logical according to the timetable of the ESPON program (Preparation of recommendation for future ESPON II) but it appears rather short (9 months), especially taking into account the fact that it starts just before a summer period which is not very favourable for the realisation of the project and for the mobilisation of researchers (who generally organise their agenda from "September to September"). Therefore, we have proposed another timetable which present many advantages and appears to fulfil better the expectation of the T.O.R. (**see. 1.2.7**)

- Concerning the deliverables, we agree with the general structure proposed in point (a)..(f) but insist on the two-step approach which implies that all methods are firstly tested on a reduced example before being applied to the whole European territory. We have also taken into account the facts that feed-backs are necessary, especially from final users (statistical agencies, policy makers in the field of spatial planning). Therefore, we propose to introduce a Draft Final Report (DFR) between the Interim Report (IR) and the Final Report (FR). The precise list of deliverables is presented in the description of each work packages (**see. 1.3**).

1.1.4 Concluding remarks on the terms of reference

The answer to the problem described in the terms of reference of the project 3.4.3 should be based on a two-step approach

Step 1 : Identification of the MAUP problem and exploration of solutions : the first problem is to propose a review of literature on the MAUP problem and to present the political consequences of MAUP to policymakers. During this step, it is important to provide typical examples of the MAUP problem and to introduce the possible solutions. This step should be realised on limited parts of the European territory and not cover immediately the full ESPON space.

Step 2 : Application of selected solutions to the ESPON database and political validation : the second problem is to select the solutions which appears the most convenient from scientific point of view and to verify (1) that they can be applied at the European scale and (2) that they are politically relevant.

The terms of reference does mainly insist on the Step 2 but, in our opinion, it is not possible to do it efficiently without sufficient exploration of the problem and the potential solution in Step 1. The choice of this two-step approach implies 12 months for the realisation of the project and another timetable than the one which is proposed in the T.O.R. **(see. 1.2.7).** We have based our answer on the assumption that this revised timetable would be accepted by the ESPON M.C. because we assume that we are not able to realise the study in the initial timetable proposed by the T.O.R. (April 2005 to December 2005)

1.2 Common understanding

According to the terms of reference, we develop here the main ideas which will be the basis of our answer to the tender.

1.2.1 Definition of main families of solutions to the MAUP

Our collective experiment indicates that solutions to the MAUP can be classified into three main families which have different advantages/disadvantages from the scientific and political points of view. **Territorial methods** are based on the research of new spatial units based on procedures of aggregation of existing official units. **Gridding methods** are based on the building of a regular division of space into territorial units of same shape or size. If data are not available at the individual level, these methods imply complex procedures of aggregation-disaggregation with ancillary variables (like CLC). **Smoothing methods** are based on the transformation of initial information into continuous measures of the phenomena through the application of various local filters. There exist also **Hybrid methods** like Tobler's pycnophylactic interpolation which do not modify the distribution of variables between territorial units but change their internal allocation.

More details are provided in the description of WP. 2 and WP.3 in **part 1.3**. See also examples of territorial methods and smoothing methods in the **Annex.**

1.2.2 Validation of solution to MAUP following a two-step approach

The validation of the best solution to the MAUP will be organised in a two-step approach. In the first step, methods will be applied to small parts of the European territory where it is possible to measure precisely the strengths or weaknesses of each solution. It is only in the second step, that the methods will be applied to the whole territory of the ESPON space. Doing so, we expect to gain a better understanding of the problem and to find more general solutions than the one that would be obtained by a direct application to the whole European territory. It will help also to describe the existence of the MAUP problem not only at NUTS2-NUTS3 levels but at more local scales (individual, NUTS 5, urban agglomeration, …).

1.2.2.1 Choice of examples to be analysed in the first step of validation

The examples which will be analysed in the first step should be selected according to various criteria which are :

1. Limited number of sample territories because resources are limited.
2. Location of sample territories in different part of Europe in order to prepare the application to the whole ESPON space.
3. Obtaining data for in-depth analysis of the MAUP Problem. The ideal situation is to obtain data at individual or household levels (Sweden) or according to a very precise territorial division (NUTS5 with very small units in France)
4. Existence of typical problems in the sample territories, either from a scientific or a political point of view.

According to these criteria and to the choice of project partners, we have selected the following sample territories for an in depth analysis of the MAUP problem

- **Northern Part of Sweden** is a very interesting case for two reasons : (1) the size of territorial units from NUTS2/NUTS3 is very large because of low population density which produce a problem of heterogeneity with the rest of Europe. This case study will be very useful for the research of optimal territorial divisions at European scale. (2) Our project partner (University Umea) can obtain census data at individual level which make possible the analysis of all potential solutions (grid, territorial division, smoothing methods) at various scale and can provide an estimation of error or biases which are introduced when full information is not available.
- **Ireland** presents a very interesting case in which to study the MAUP because it is now possible to examine data compatibility between the Republic of Ireland and Northern Ireland (the latter being part of the United Kingdom). In this study data drawn from Enumeration Districts (EDs) in counties in the Republic of Ireland adjacent to the border with Northern Ireland will be used in conjunction with data drawn from output areas in Northern Ireland which lie close to the border with the Republic. The two sets of units, emanating from different national statistical offices, are quite different in average size (output areas in Northern Ireland are typically much smaller than EDs in the Republic) and so provide a very interesting case study for the MAUP. The use of this area, given the massive political issues that straddle the border, make it even more useful from a policy perspective.
- **Germany** is an interesting case because it is one of the states of Europe where the NUTS 3 divisions are the smallest and where the federal system (Länder) introduce strong constraint in the choice of aggregative methods (high level of heterogeneity in terms of population and superficy). Germany is also interesting because of the important work realised by W.D. Rase on smoothing methods and their cartographic representations.
- **Additionally, the France/Belgium border** will be analysed in the Interim Report because it is a canonical example of heterogeneity of NUTS divisions at all levels. Whatever the NUTS level (5, 3 or 2) the spatial units are much more smaller in Belgium and not comparable to the ones of France. The previous research developed about the MAUP in Europe has always been applied to this example of the France/Belgium border because it is one of the most difficult but also the most typical (**see. Annex 2.2**)

These samples cover many different aspects of the MAUP and are probably sufficient for the first level of the test phase. To be complete, it would probably be useful to introduce a specific case study on the MAUP in urban agglomeration (NUTS units do not fit with morphological or functional delimitation of towns) but it is a very specific problem which would probably deserve another ESPON policy support project. It has indeed been announced that an ESPON Project will be launched on the question of the delimitation of urban areas which was recognised as a major problem in final report of Project 1.1.1 and 1.2.1. The study ESPON 3.4.3 will provided inputs for this question but not analysed it precisely as it is very complex and need specific expert contributions which are out of the range of actual T.O.R..

1.2.2.2 Choice of variables to be analysed in the second step of validation

In this second step, the objective is to apply the best solutions of the MAUP found at Step one to the European scale (EU29) in order to produce a series of map which can be compared and evaluated by policy makers. The terms of reference indicate that these maps *"are to be selected in co-operation with the ESPON CU and tested according to their readability and acceptance by policy- makers in various policy fields. The policy fields to be covered will include regional policy, transportation policy, telecommunication policy, research and development policy, and common agricultural policy."* It is therefore very clear that the precise list of variables to be used for the experiments are not actually decided and will be chosen in accordance with the proposals of the CU and the MC of the ESPON Program. At present, we can not decide what is the most politically relevant but we can indicate some principles of selection which appear to us the most important from a scientific point of view :

1. Limit the experimental variables or topics because for each topic we will produce a huge number of solutions and it is better to work intensively on the MAUP rather than producing a new ESPON atlas which is not the objective of the study.
2. Select variables which are of varying sensitivity to the MAUP. For example, the density of population is less sensitive than a rate of population variation to the MAUP problem and it will be interesting to compare the behaviour of both kind of variables.
3. Select variables which are politically "sensible" because it will help to with the acceptability of the results by policymakers. Accordingly, GDP/person. or Unemployement Rate are very interesting as they are classically the basis for the allocation of structural funds.
4. Select at least one variable which combines environmental and socio-economic databases. The MAUP appears to be related to the possibility of combining information reported for different territorial divisions like CLC and REGIO. We could therefore imagine computing a ratio of "Natural Area per inhabitant" which will typically combine information on land use and information on population. This would assist the contacts to be developed with Eurostat, EEA and JRC which are all interested in such combinations.
5. Select at least one variable related to an evolution through time, because the dynamics are a very specific problem and all rates of variation are very sensitive to MAUP as explained above. But, and it is a very interesting issue, the solution to the MAUP can make possible the evolution of a variable despite the modification of territorial units.

As a preliminary proposal, we could therefore suggest the following list of indexes which fulfil these requirements :

- **Population density** (or other measures of population distribution)
- **GDP/person** (or other measures of the unequal distribution of wealth)
- **Unemployement rate** (or other measure of accessibility to labour market)
- **Evolution of population** (at different time periods : 1995-2000, 1980-2000, …)
- **Natural area per inhabitant** (or equivalent index of accessibility to a type of land use)

1.2.3 Connexion of project 3.4.3 with the ESPON network

The proposed work will be realised in strong connexion with the ESPON Network .

- **Utilisation and development of previous results of ESPON projects** : We propose to use some previous results of the ESPON Program in our work on MAUP, as it is suggested in the T.O.R. In particular, we propose to use the results of projects 1.1.1, 1.1.2, 1.2.1 and 3.1 which has direct implications for the solutions to the MAUP.

- **Connexion with currently running ESPON Project :** Through the Lead Partner meetings and the ESPON meetings, we will find many opportunities to discuss our solution to MAUP with TPG having encountered the problem. In accordance with the CU, we could select for test phase 2 some variables which are actually under investigation by other TPG's. For example, the project ESPON 3.2 try to develop a long term database where one of the crucial problem is the change of spatial units through time. Project 3.4.1 (Europe in the World) will be also interested by the result as the MAUP problem is also present at world scale (heterogeneity of size of states). Therefore, it could be interesting to work together with them on possible solutions for the cartography of indicators at different period of time when territorial divisions are changing.

- **Connexions with Eurostat, EEA and JRC** : Having been in contact with these organisation out of the ESPON Program, we know that they have been regularly been in contact with the MAUP problem and are looking for solutions. In particular, Eurostat has launched in 1996 a tender which was precisely related to the problems of heterogeneity of NUTS units, which is an excellent basis for the work to be develop in ESPON 3.4.3. At the same time, EEA has tried to proposed smoothing methods applied to CLC (Corilis project) on which we contributed as expert and have kept regular contacts. Concerning JRC, they have developed an in depth analysis of the problem of re-allocation of socio-economic data by mean of ancillary variables derived from Corine database and can provide good expert advice for all topics related to mixture of socio-economic and environment data. The project ESPON 3.4.3. will be a very good opportunity to intensify these informal contacts and to gain reciprocal experiment. For more details, see. **WP. 4.1**

- **Evaluation of proposals by CU, MC and ECP Network** : The key point of the project is of course the final evaluation of proposals of new cartographic representations and solutions to the MAUP by final users. This step will be normally organised by the CU but we propose to make more easy this test phase by the elaboration of evaluation grids and eventual analysis. We suggest also to include the ECP network in this evaluation of the results, in order to enlarge the panel of final users on which solutions will be tested. As they are several ECP in our group (France, Belgium, Ireland), this implication of ECP network is easy to realise. For more details, see. **WP. 4.2**

1.2.4 Selection of project partners and experts

Despite the limited allocation of funds, we have decided to include several teams in the project as expert or partners, because the subject is very difficult and request very high level capacities which can not be found in isolated research teams.

1.2.4.1 Lead partner

The leading of the project will be shared between **UMS RIATE (French ECP)** and **UMR Géographie-cités (Paris, France).**

- **UMR Géographie-cités (FRA)** is a reference team in France and Europe for research on spatial analysis, quantitative geography and European Spatial Planning. This team will insure the scientific coordination of the project and insure full responsibility for all questions related to research. In practical terms, it means that UMR Géographie-cités will focus on the coordination of the first step of the analysis of the MAUP Problem **(WP1 & WP2).**

- **UMS RIATE :** The administrative coordination (signature of the contract, network organisation, preparation or reports) will be insured by the french ECP UMS RIATE which is a "Service Unit" specialised in these tasks. The UMS RIATE will also provide all technical supports for the elaboration of databases, harmonisation of maps, preparation of reports, networking with ESPON, … which are not directly scientific tasks but are absolutely necessary conditions for the success of the project. As ESPON Contact Point, UMS RIATE has good experiment of the process of political validation of scientific results and will insure the coordination of results of second step of validation at European scale **(WP3 & WP4).**

The division of the leadership is not a problem because the responsible of the project, is at the same time director of UMS RIATE and advice director of UMR Géographie-cités. Both teams are also administratively linked with University Paris 7 which is the legal authority of the contract. **Claude Grasland** which has a good experiment of the ESPON program will be particularly involved in the realisation of WP. 3. **Léna Sanders**, Director of UMR Géographie-cités and international specialist from theoretical geography will be more specifically involved in the coordination of WP. 2.

1.2.4.2 Project partners

We have selected 3 teams of different countries of Europe with recognised and complementary experiment in the field of the MAUP. Each project partner is supposed to provide at the same time a theoretical and empirical expertise of the problem.

- **University of Umea (SWE)** provide an exceptional competence for the analysis of data at micro/macro level, taking benefit from the existence of the most detailed census data in Europe. They will provide a general expertise on the effect of

aggregation on the degradation of information through the case study of northern part of Sweden. The responsible of participation in Project 3.4.3 is **Einar Holm.**

- **IGEAT (BEL)** provide a long term experiment of the NUTS2/NUTS3 problem, in partnership with UMR Géographie-cités. Both teams has developed common databases at this level (Euroscope) and published several Atlas about demography or economy of Europ using a mixture of NUTS2 and NUTS3. The responsible of participation in project 3.4.3 are **C. Vandermotten.**

- **NCG (IRL)** is a research team at European and world level in the field of spatial analysis, statistical analysis and GIS. They provide a very good knowledge on statistical problems related to the MAUP and have developed possible solutions to it like GWR (Geographically Weighted Regression). In partnership with the Irish ECP, they will provide a case study on the border region between the Republic of Ireland and Northern Ireland where very different reporting units exist on either side of the border. The leaders from the NCG in project 3.4.3 are **S. Fotheringham.**

1.2.4.3 Experts

We have selected 3 expert teams which will provide specific contribution for the successful realisation of the project.

- **CESA (FRA)** which was former leader of project 1.2.1 on accessibility will provide a specific contribution for the realisation of accessibility matrixes (time distance) at different level of aggregation (NUTS2, NUTS3, Grid) and for the whole ESPON area (EU 29). The CESA will also provide an innovative tool ("Oculographe") for the analysis of the perception of the cartographic message delivered by maps to final users. The responsible of participation in ESPON 3.4.3 is **P. Mathis**.

- **ID-IMAG (FRA)** is a research team in computer science specialised in parallel computing which has yet participate to the realisation of the ESPON Hyperatlas in the framework of ESPON 3.1. This team will firstly provide resources for computation on very large databases like CLC or for smoothing at high level of details. In connexion with RIATE, they will also provide innovative solutions for the cartographic transmission of maps to final user, like Hyperatlas or animated maps The responsible of participation in ESPON 3.4.3 is **J.M. Vincent**.

- **BBR (GER)** will be present at expert level for a specific contribution on Tobler's pycnophylactic method and also for expertise on the cartographic representation of smoothed maps. On both subjects, the BBR provide a very good expertise through a researcher specialised in these topic, **W.D. Rase**.

1.2.4.4 Possible enlargement of the group to associated and new members countries

Due to the limited allocation of funds, it was not realistic to build a too large network of teams for the answer to this tender. But it is important to observe that during the last weeks of preparation of the answer, we have received many proposals of participation which could be

very interesting in the last stage of scientific and political validation of proposals of solution to the MAUP.

It is obvious, for example, that the question of territorial division is very specific in new members countries (Poland, Romania, …) where dramatic changes in administrative units took place after the fall of the iron curtain in 1989 and where many constraints where imposed by European Union during the phase of pre-adhesion ("acquis communautaire") where candidate countries was obliged to elaborate new territorial divisions at NUTS level. Even in the case of associated countries (Switzerland, Norway), there has been strong internal discussion for the elaboration of new statistical territorial division able to insure a compatibility with the NUTS system of EU.

For these reason, **we will propose to the ESPON MC to provide an additional budget** which could make possible the association of the two following research teams which had proposed to join our group :

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If the ESPON MC agree to this proposal, these teams would be involved as expert and provide important feed-backs on the specificity of territorial divisions in neighbouring countries (Pr. Martin Schuler, EPFL) and new member countries (Prof. Tadeusz Sumien, ISEH). Their contribution would be especially precious for WP. 3 and WP. 4.

1.2.5 Global organisation of work

The project is divided in 4 work packages which follows the logical order described in previous sections (**see. also Figure in part 2**.)

1.2.5.1 WP1: Initialisation of the project

- Insure the organisation of meeting, the building of an Intranet website, the relations with ESPON CU, the preparation of Interim and Final Reports.
- Administrative fees of University Paris 7

1.2.5.2 WP2: State of the art – Test on sample areas

- This work package proposes firstly an inventory of solutions proposed by research teams or available in the scientific literature and previous applied research in the field of spatial planning.
- This solutions are then tested and applied on the sample areas provided by research teams in order to evaluate their advantage/inconvenient.
- A selection of most interesting methods is proposed for WP3

1.2.5.3 WP3: Application of solutions to Europe – Cartography - Comments

- Solutions are applied to the whole European territory with help of experts
- Resulting maps are classified and differences are analysed and commented by project partners
- Eventually, specific support are introduced (animated map, website, CD-Rom, …)

1.2.5.4 WP4: Evaluation – Feed Backs – Recommendations

- Presentation of results to ESPON community (policymakers, researchers …)
- Feed-backs, discussions
- Recommendation for future ESPON work
- Dictionary of selected tools

This organisation of work can give the feeling that our research group is divided in two separated streams :

- N**CG, UMEA, GEOGRAPHIE-CITES & BBR** concentrate on theoretical aspects and their validation at local scale *(WP2)*
- **RIATE, IGEAT, CESA & ID-IMAG** concentrate on empirical application and political validation at European scale *(WP 3)*

In fact, this separation is mainly a practical way to produce efficient results in a short period through a strong division of work and a clear allocation of responsibility. But the feeling of the leader (and the feed backs of research teams) indicates that each team are in fact interested to contribute to both step of the analysis. In other words, the realisation of the project will associate all partners' teams in each step, but with more or less level of responsibility. This flexible approach will insure at the same time a great efficiency (division of work with responsibilities) and a high level of quality (control of the work of each team by other members of the group).

1.2.6 Synthetic timetable

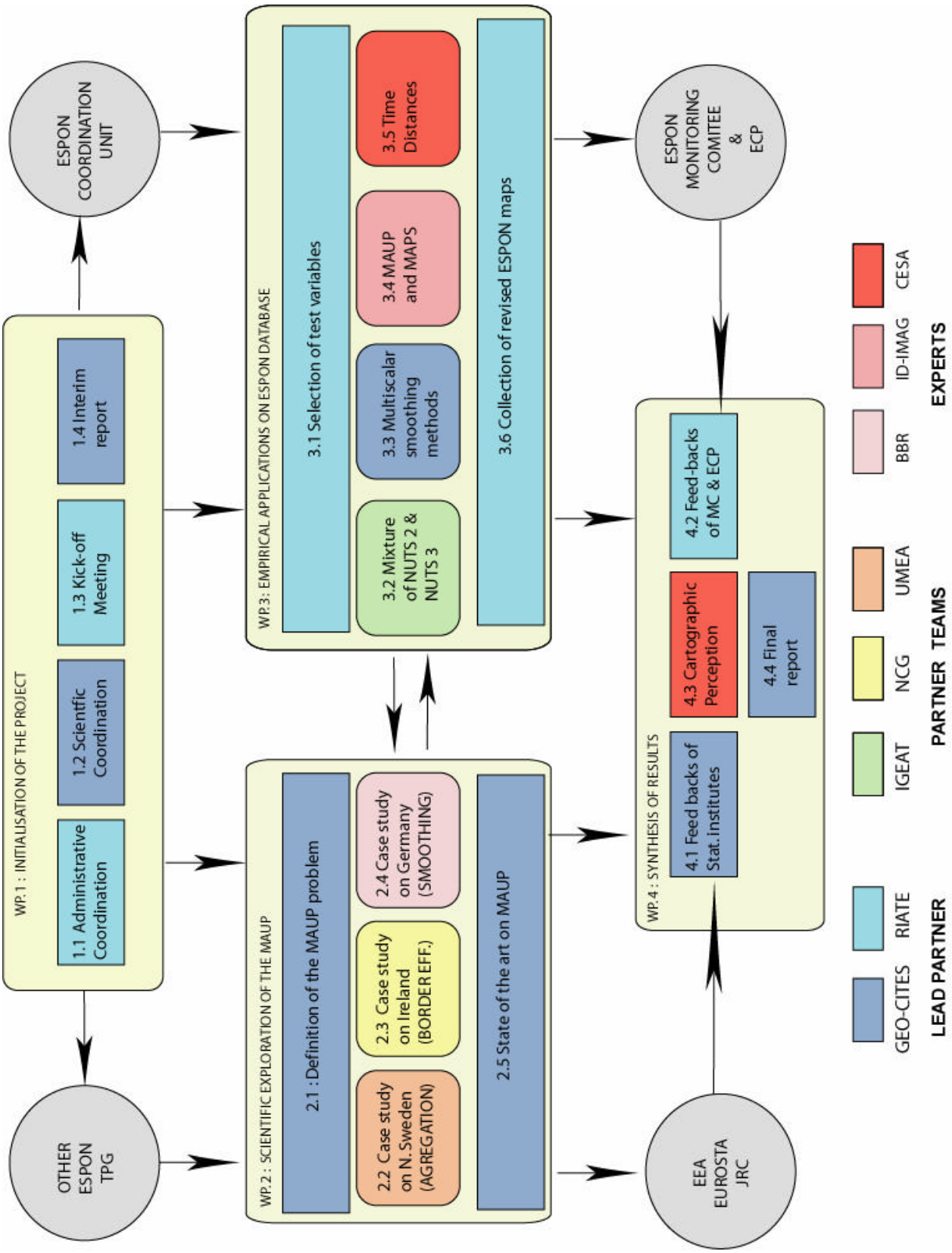
The research teams involved in our answer to the tender ESPON 3.4.3 has examined in detail the timetable proposed in the terms of reference (April 05 to Dec. 05) and have concluded that it is not possible to do so if we want to develop the 2-step approach that we propose and if we want to obtain regular feed-backs from ESPON community.

- **June 2005**: Beginning of the project - Kick-off meeting in Paris (2 days)
- **Sept 2005**: Delivery of Interim report : presentation of first results on MAUP from theoretical point of view - Proposals for empirical application on Europe
- **Oct. 2005** : Discussion of our proposal by the ESPON Meeting (scientists +policy makers)
- **Dec. 2005**: Internal meeting.
- **April 2006**: delivery of our Draft Final Report. Conclusion on theoretical approach of MAUP - Presentation of new collection of maps at European scale
- **May 2006**: Discussion of our conclusions and proposals by the ESPON Meeting (scientific validation & political validation)
- **June 2006**: delivery of final report taking into account feed-backs at scientific and political levels.

This proposal of modified timetable has many advantages for the realisation of the project ESPON 3.4.3.

1. *The fact to start in June 2005 give the insurance that all administrative problems will be solved before the beginning of the project (signature of contract, subcontract, …)*
2. *The fact to deliver the Interim Report in September 2005 give the opportunity to have very early feed backs from the ESPON community (scientists and policymakers) during the ESPON meeting of October 2005. These feed backs after 3 months will make the project more efficient and flexible.*
3. *The biggest part of the work will be realised between October 2005 and March 2006 which is more convenient for research team (no interruptions related to summer holydays)*
4. *The fact to deliver a Draft Interim Report in March 2006 make possible the elaboration of feed backs from policy-makers on the collection of revised ESPON maps at European scale. The new maps will be presented and discussed during the ESPON meeting of May 2006.*
5. *The Final report delivered in June 2006 will take into account the feed-backs from policy makers and insure the political validation of proposed solution, which is a major topic of the T.o.R.*

2 WORK PACKAGES



2.1 WP 1: INITIALISATION OF THE PROJECT

Objective: The objective of this workpackage is to fulfil all tasks related to the scientific and administrative organisation of the project, including the elaboration of the intranet, the kick-off meeting and the preparation of the Interim Report.

Teams involved: GEOGRAPHIE-CITES, RIATE, All

Organisation:

WP 1.1 Administrative coordination & Intranet (RIATE)

WP 1.2 Scientific coordination (GEOGRAPHIE-CITES)

WP 1.3 Kick-off meeting (RIATE+All)

WP 1.4 Interim Report (GEOGRAPHIE-CITES+All)

Deliverables & Timetable:

Code	Description	Responsible	Date
D.1.a	Contract & subcontracts with partners	RIATE	May 2005
D.1.b	Intranet of Project 3.4.3	RIATE	June 2005
D.1.c	Organisation of Kick-off meeting	RIATE	June 2005
D.1.d	Delivery of Interim Report	GEOGRAPHIE-CITES, All	Sept. 2005

Precise description of work realised in WP 1 {1 page}

WP 1.1 Administrative coordination & Intranet (RIATE)

This work package should cover all the administrative and financial work. The elaboration and conception of the financial reports, the gathering of financial data, invoices or administrative documents will be done by UMS RIATE. A full-time engineer, Isabelle Salmon (administrator in charge of financial matters from UMS RIATE) will be mainly in charge of these tasks. She will be helped by the University Paris 7 accounting office.

The UMS Riate ensures since 2002 an active participation in the frame of the Espon program which leads to some conclusions on the usefulness and limits of the virtual networking. Following the experience gained under the TPG 3.1, 3.2 and 3.4.1, the UMS Riate, through its web-documentation engineer, can provide to the members of the consortium 3.4.1 a coherent and efficient set of Internet, Extranet and Web tools. We propose some originals applications, like controlled Extranet "Duevera Groupware" with several thematic working groups, Mailing-Lists, Webmail, Ftp access, Web sites with graphic resources which will ensure a good diffusion, and a good sharing of informations, files, ideas… This infrastructure is very crucial to allow discussions and to strengthen the relations between each member of the European consortium. The work of intranet will be insure by an engineer of UMS RIATE (Bernard Corminboeuf) specialised in the question of cooperative work by internet and scientific documentation.

WP 1.2 Scientific coordination (GEOGRAPHIE-CITES)

Concerning the scientific coordination the leader of the project (Claude Grasland) will be assisted by a scientific coordinator in the framework of a post-doctoral contract[1]. The scientific coordinator will insure the continuous task of networking with all the partners, request for deliverables, preparation of interim reports, control of timetable, preparation of meetings, development of documentation, animation of forum on key-questions on the website…

Due to the responsibility of UMS RIATE as French Espon contact point, the networking with other TPG will be necessarily very active and feedbacks will be obtained from other ECPs.

WP 1.3 Kick-off meeting (RIATE)

The kick off meeting organised in Paris at the very beginning of the project (June 2005) will focus on the immediate beginning of research to be developed in WP.2 and WP.3 and on the preparation of the Interim Report to be delivered in September 2005. We strongly suggest to **invite the ESPON CU to take part to this kick off meeting** in order to solve many open questions as the choice of test variables which will be used for the realisation of maps at European scale. There would also be very useful to have **representative of European**

[1] The scientific coordinator will be Clarisse Didelon which achieved a Ph'D on the effects of globalisation on silk trade in India

statistical agencies at this kick-off meeting (EEA, Eurostat, JRC) but we are not able to take the responsibility of fees for the invitation of these external experts.

WP 1.4 Interim Report (GEOGRAPHIE-CITES, RIATE, All)

The main target of the IR is to propose at an early stage of the research (3 months) an overview of the MAUP problem and the directions that will be followed by the group in order to analyse it in depth (WP.2) and propose empirical solutions which can be used at European scale (WP. 3). **The basic idea is that this report will be analysed by ESPON MC members at the ESPON meeting of October and will provide very useful preliminary feed-backs before to engage the main part of the work**.

Our idea is to prepare a **short report** (30 p. + Annex) which can be read very easily by the members of the ESPON MC and present them the following topics :

- **What is MAUP ? :** Through the presentation of typical example encountered in the ESPON Program or studies at other scales .
- **Why is it important for ESPON ?** : Precise description of typical situations where political decision is influenced by MAUP. It will be mainly a development of the initial work developed by project ESPON 3.1.
- **Why is it important to produce an in depth analysis of the problem ?** This part will be realised by teams involved in WP.2 which will explain the interest of the specific analysis of part of the European territory (Ireland, Northern Sweden, Germany).
- **How we propose to challende the MAUP at European Scale ?** This part will be realised by teams involved in WP. 3 which will explain the directions they will follow to propose new maps and new tools and for which indicators they will realised experiments.

2.2 WP 2: SCIENTIFIC EXPLORATION OF THE MAUP

Objective: This work package realise a state of the art of the literature on MAUP and propose an inventory of solutions proposed by research teams or available in the scientific literature. The different solutions are tested and applied on specific sample areas provided by research teams in order to evaluate their advantage/inconvenient. A selection of most interesting methods is proposed.

Teams involved: GEOGRAPHIE-CITES, NCG, UMEA, BBR

Organisation:

WP 2.1 Definition of the problem (Géographie-cités)

WP 2.2 Test on Sweden (UMEA)

WP 2.3 Test on Ireland (NCG)

WP 2.4 Test on Germany (BBR)

WP 2.5 Scientific recommendations (GEOGRAPHIE-CITES, All)

Deliverables & Timetable:

Code	Description	Responsible	Date
D.2.a	State of the art - Preliminary definition of the MAUP - Typical examples (IR)	GEOGRAPHIE-CITES, All	Sept. 2005
D.2.b	Description of the objective of each tests study (IR)	UMEA, NCG, BBR	Sept. 2005
D.2.c	Results of the test study & Scientific recommendations (draft FR)	UMEA, NCG, BBR, GEOGRAPHIE-CITES	April. 2006

Precise description of work realised in WP 2

WP 2.1 Definition of the problem (GEOGRAPHIE-CITES, All)

The responsibility of the scientific lead partner is to propose a definition of the problem which will combine two dimensions :

(a) the scientific dimension which will be based on a synthesis of existing literature on the MAUP, realised in common with other partner teams. A particular focus will be made on **the case of the French-Belgium** border which has been subject of many research papers on the MAUP and is considered as the typical example by scientists (**see. Annex 4.2**)

(b) the empirical dimension which will be based on a synthesis of applied research in the field of spatial planning which has encountered the MAUP Problem. It will be based of course of ESPON and SPESP studies, but also on research developed by European statistical agencies. An input of particular interest will be **the report realised** for Eurostat-GISCO in the framework of the SUPCOM 95 project[2]. This study generally failed to provide efficient solution to the MAUP problem, but has the great interest to have yet provide a large synthesis on the subject.

WP 2.2 Case study on Sweden – Aggregation problem (UMEA)

University of Umea provides an exceptional competence for the analysis of data at micro/macro level, taking benefit from the existence of the most detailed census data in Europe For some years longitudinal individual information with high temporal and spatial resolution has been made available for research. The ASTRID research database contains such individual annual register information from Statistics Sweden for each individual in Sweden 1985-2002. For each person, the database contains some hundred attributes, i.e. age, sex, immigration origin and year, family, education, incomes and benefits, size, land use and value of owned land properties, place of living and work with 100 meters resolution etc. The purpose of the database and the reason for permission to use the data is for developing spatial micro simulation models at SMC (Spatial Modelling Centre) in Kiruna. SMC is a research unit within the department of social and economic geography at Umeå University.

Due to access to this data we can avoid much of the Modifiable Areas Unit Problem. However, we can also avoid some of the more general problem behind MAUP: For what kind of research problems does aggregation (not only spatial) prior to analysis bias results? Of course, micro results are biased or non existent without individual data – but is that also the case for all kinds of aggregated results? Are all demographic and socioeconomic problems equally sensitive to early aggregation? One hypothesis is that i.e. simple regional demographic projections and descriptions not necessarily become better based on individual information as compared to regionally disaggregated tables. The main uncertainties are anyway not buried in observable individual attributes but rather in changes in attitudes and regional economic performance. Phenomena where scale and heterogeneity in the process matters more for the outcome might give other results. Unemployment is the result of matching local supply and demand within a very diversified labour market. The detailed individual composition of competences and requirements should matter. We propose to investigate three examples, the regional and local distribution of population, incomes and unemployment respectively. Indicators like percentage 65+, mean age, crossectional fertility, income level, income distribution, unemployment level and distribution etc. are constructed. Results with measurements on individual level are compared to results based on data aggregated to administrative regions like parish, municipality and county. We also compute

2

http://europa.eu.int/comm/eurostat/research/index.htm?http://europa.eu.int/en/comm/eurostat/research/supcom.95/&1

measures based on different ranges centred around individual 100 meter squares, like ranges with a radius of 500 meters, 5 km and 50 km. This experiment will give information whether or not the use of administrative regions distort results compared to using ranges on corresponding spatial scales centred around the acting individuals themselves. They will provide a general expertise on the effect of aggregation on the degradation of information through the case study of northern part of Sweden.

The responsible of this W.P. 2.2 is Einar **Holm.**

WP 2.3 Case study on Ireland – Border effect problem (NCG)

NCG (IRL) is a research team at European and world level in the field of spatial analysis, statistical analysis and GIS. They provide a very good knowledge on statistical problems related to the MAUP and have developed possible solutions to it like GWR (Geographically Weighted Regression). In partnership with the Irish ECP, they will provide a case study on the border region between the Republic of Ireland and Northern Ireland where very different reporting units exist on either side of the border.

Ireland presents a very interesting case in which to study the MAUP because it is now possible to examine data compatibility between the Republic of Ireland and Northern Ireland (the latter being part of the United Kingdom). In this study data drawn from Enumeration Districts (EDs) in counties in the Republic of Ireland adjacent to the border with Northern Ireland will be used in conjunction with data drawn from output areas in Northern Ireland which lie close to the border with the Republic. The two sets of units, emanating from different national statistical offices, are quite different in average size (output areas in Northern Ireland are typically much smaller than EDs in the Republic) and so provide a very interesting case study for the MAUP. The use of this area, given the massive political issues that straddle the border, make it even more useful from a policy perspective.

The responsible from the W.P. 2.3 are **S. Fotheringham and M. Charlton**.

WP 2.4 Case study on Germany – Tobler's method (BBR)

Smooth pycnophylactic interpolation is a method proposed by Waldo Tobler which has been further developed by other researchers, especially W.D. Rase from the BBR This method produces a smooth result but, at the same time, it takes into account a territorial constraint because the global volume of each territorial unit is maintained. In other words, the interpolation procedure takes place only inside the territorial units where the values are located. It is therefore very different to the other smoothing methods which do not introduce this constraint. This method is also related to gridding because it can be a very simple and powerful solution for the reallocation of information from non-regular territorial divisions to a regular grid.

A specific discussion of the advantages of this approach will be realised by **W.D. Rase**.

WP 2.5 State of the art on the MAUP (GEOGRAPHIE-CITES, All)

In the Final Report, a synthesis of the work realised by all teams involved in WP. 2 will be realised which will provide a "state of the art" on the MAUP problem. Each solution will be carefully assets and illustrate by example. This part of our final report intend to be a reference work for further research to be developed by ESPON II.

2.3 WP 3: EMPIRICAL APPLICATIONS ON ESPON DATABASE

Objective: The objective of this work package is to explore selected solution to the MAUP on the ESPON database in order to produce maps than can be evaluated by policy makers. As regard to previous work done in the ESPON program, the work package will focus on territorial solutions (mixture of NUTS units) and multiscalar smoothing methods. With the technical support of experts, some innovations will be introduced like the introduction of time distance in smoothing procedures or the attempt to elaborate functional NUTS2/NUTS3 regions.

Teams involved: GEOGRAPHIE-CITES, RIATE, IGEAT, CESA, ID-IMAG

Organisation:

WP 3.1 Selection of test variables (RIATE)

WP 3.2 Test of territorial methods (IGEAT)

WP 3.3 Test of smoothing methods (RIATE, GEOGRAPHIE-CITES)

WP 3.4 MAUP & MAPS (ID-IMAG)

WP 3.5 Functional distance (CESA)

Deliverables & Timetable:

Code	Description	Responsible	Date
D.3.a	Selection of test variables in accordance with ESPON CU	RIATE	June 2005
D.3.b	Precise description of the maps to be elaborated by smoothing or territorial methods – Sample of results (IR)	IGEAT, GEOGRAPHIE-CITES, RIATE	Sept. 2005
D.3.c	Results of the test & Policy recommendations (draft FR)	IGEAT, GEOGRAPHIE-CITES, RIATE	April 2006
D.3.d	Proposal of methodology for map comparison & perception (draft FR)	CESA, ID-IMAG	April 2006

Precise description of work realised in WP 3

WP 3.1 Selection of test variables (RIATE)

The objective is to apply the best solutions of the MAUP found at Step one to the European scale (EU29) in order to produce a series of map which can be compared and evaluated by policy makers. The terms of reference indicate that these maps *"are to be selected in co-operation with the ESPON CU and tested according to their readability and acceptance by*

policy- makers in various policy fields. The policy fields to be covered will include regional policy, transportation policy, telecommunication policy, research and development policy, and common agricultural policy." It is therefore very clear that the precise list of variables to be used for the experiments are not actually decided and will be chosen in accordance with the proposals of the CU and the MC of the ESPON Program. At present, we can not decide what is the most politically relevant but we can indicate some principles of selection which appear to us the most important from a scientific point of view:

- Limit the experimental variables or topics (3 maximum) because for each topic we will produce a huge number of solutions and it is better to work intensively on the MAUP rather than producing a new ESPON atlas which is not the objective of the study.
- Select variables which are of varying sensitivity to the MAUP. For example, the density of population is less sensitive than a rate of population to the MAUP problem and it will be interesting to compare the behaviour of both variables.
- Select variables which are politically "sensible" because it will help to with the acceptability of the results by policymakers. Accordingly, GDP/person. or Unemployement Rate are very interesting as they are classically the basis for the allocation of structural funds.
- Select at least one variable which combines environmental and socio-economic databases. The MAUP appears to be related to the possibility of combining information reported for different territorial divisions like CLC and REGIO. We could therefore imagine computing a ratio of "Natural Area per inhabitant" which will typically combine information on land use and information on population. This would assist the contacts to be developed with Eurostat, EEA and JRC which are all interested in such combinations.
- Select at least one variable related to an evolution through time, because the dynamics are a very specific problem and all rates of variation are very sensitive to MAUP as explained above. But, and it is a very interesting issue, the solution to the MAUP can make possible the evolution of a variable despite the modification of territorial units.

As a preliminary proposal, we could therefore suggest the following list of indexes which fulfil these requirements:

- **Population density** (or other measures of population distribution)
- **GDP/person** (or other measures of the unequal distribution of wealth)
- **Unemployment rate** (or other measure of accessibility to labour market)
- **Evolution of population** (at different time periods: 1995-2000, 1980-2000 …)
- **Natural area per inhabitant** (or equivalent index of accessibility to a type of land use)

WP 3.2 Test of territorial methods (IGEAT)

The principle of territorial methods is to change an initial partition of space into another one by mean of aggregation or disaggregation procedures.

- **From the scientific point of view**, the general problem is the reduction of the heterogeneity of territorial units according to various criteria like superficies, population, functionality … Generally, this reduction of heterogeneity can only be obtained through a reduction in the number of territorial units, which implies a loss of information on the target phenomena. The problem is therefore a problem of optimisation in order to realise the best balance between (1) the homogeneity of resulting units and (2) the number of resulting units. If one tries to obtain a perfect homogeneity, we take the risk of reducing dramatically the initial information. But if we try to save too many of the original territorial units, we take the alternative risk of having a high level of heterogeneity which introduces biases in the analysis.

- **From the political point of view,** the problem is different and is based on another balance between scientific quality and political relevance of the results. As a very simple example of this problem, we can consider that a full set of actual NUTS 2 or NUTS 3 divisions is politically relevant because it is immediately acceptable and adapted to political decisions which are based on these official units; but it produces results of low scientific quality because the territorial units are not homogeneous according to many criteria (especially in terms of population, superficies and polarisation by an urban centre). On the opposite side, a new aggregation of territorial units which would produce "unofficial NUTS" (like Bruxelles +North Brabant +South Brabant or Luxembourg + the nuts3 regions of France, Belgium and Germany) would be scientifically justified because they increase the homogeneity and functionality of the area; but they can create at the same time a political problem because such units do not respect the official political delimitation at intranational or international levels.

- **Use of previous ESPON results**: . In the case of project 1.1.1. and 1.1.2, our intention is to use the results on polycentrism and urban-rural relationships for the elaboration of a "functional NUTS2/NUTS3" level which would be characterised by the existence of a main urban centre (or a cluster of centre) in each target region. For example, we can start from the list of MEGA and realised an allocation of NUTS3 units to the MEGA with which they have the most important potential relations, according to a gravity model (Reilly, Huff or equivalent). In the case of project 1.2.1, see W.P. 3.4.

- **Expected outputs :** we propose to elaborate a minimum of 3 different proposals of mixture of NUTS2 and NUTS3 territorial units : **(a) Maximum areal homogeneity** will try to obtain territorial units of equal superficy under various constraint ; **(b) maximum demographic homogeneity** will try to obtain territorial units of equal population ; **(c) Maximum functional integration** will try to obtain territorial units consistent from economic point of view with polarisation around one metropolis or a polycentric cluster of urban units.

WP 3.3 Test of smoothing methods (RIATE, GEOGRAPHIE-CITES, ID-IMAG)

Smoothing methods introduce a paradox because they are scientifically very complex and abstract but our experiments indicate that they are often at the same time considered as "simple and concrete" by policymakers.

- **From the scientific point of view,** "smoothing methods" is the general name for different sets of tools which are based on very different methods from statistical and theoretical points of view. For example, in "smoothing methods" applied to **continuous phenomena** it is normally possible to measure directly the target phenomena Z in each point (x,y) of the area. In this case, "smoothing methods" are related to the theory of probability and the general question is how to build a general measure Z(x,y) in all points of the area with a limited sample of empirical values of Z. Typically, the solution is based on statistical methods (Shepard, Kriging, …) which have been applied for a long time to the realisation of maps of temperature or altitude. But the data which are generally analysed by spatial planners do not fulfil this condition of continuity and, basically, are related to phenomena with **discrete or discontinuous spatial distribution**. As an example (for more details, see. Grasland, Mathian & Vincent 2000) the realisation of a map of population density can not be done with usual statistical interpolation methods like kriging because the phenomena is not continuous and it is impossible to define objective "exact values" in a given point of space (x,y) with null surface. The measure of population density is always related to the introduction of a **specific filter** by the observer. This filter can be an administrative unit (density of population inside a region), a geometric filter (density of population in a circle with radius 50 km) or even a functional filter (density of population in a fuzzy neighbourhood based on the decrease of relation with time distance). In fact the use of **parametric filters** (e.g. density of population in a circle with growing radius) is very useful for the realisation of multiscalar analysis where the smoothing of the phenomena is gradually increased. It is therefore possible to define optimal filters according to the target of the study and the initial level of aggregation of the information. Empirical studies on Gaussian smoothing filters has for example demonstrated that when the purpose is to keep maximal information (spatial resolution) with elimination of initial uncertainty (data are not available at individual level but in territorial units), it is necessary to choose a span of neighbourhood which is more or less equal to 2 times the radius of basic territorial units (Hypercarte, 2000).

- **From the political point of view**, smoothing methods presents several advantages/disadvantages. (a) The fact that the measures of the phenomena are not related to a precise territorial unit but to a fuzzy neighbourhood without exact borders is at the same time an advantage (because it forces the policymaker to focus on the general distribution of the phenomena and not on the specific value of its own territory – my region, my town) but it is also an inconvenience because it makes the application of operational political decisions (which are generally based on precise delimitations) more difficult. (b) The fact that initial distributions are smoothed is very interesting for studies on polycentrism because it seems possible to avoid the difficult problem of the initial delineation of aggregates (MEGA) and to propose maps where clusters of separated poles are combined in a global peak ; but this approach can also be considered as dangerous because it is not necessarily true that 4 peaks of 1 million inhabitants have the same functional importance as a unique peak of 4 million inhabitants, depending on agglomeration effects and externalities related to size. (c)

The fact that parametric smoothing methods can help to produce a continuum of representations of the same phenomena more or less generalised is a precious advantage for the development of a multiscalar approach, but it can also be considered a disadvantage when too many solutions are proposed and when the policymakers try to define one best solution for the application of a given policy

- **Use of previous ESPON results**: Concerning project 3.1 we will obviously use the preliminary results about MAUP which were presented in the FR (it is relatively easy as the author of this study for 3.1 is the leader of the present project 3.4.3 …).

- **Expected outputs :** This work package will deliver minimum three different outputs : **(a) a set of smoothed maps of a socio-economic indicator at different scale according to euclidean distance or time distance**. This will be probably based on the criteria of GDP/inh. and unemployement rate. **(b) a example of smoothed map combining environmental and socio-economic data** which will be probably based on a combination of CLC and SIRE databases**. (c) An example of smoothed map of evolution through time of a given index** where territorial units are changing, in order to demonstrate the interest of smoothing methods for this particular situation.

WP 3.4 MAUP & MAPS (ID-IMAG, RIATE)

We consider that the solution to the MAUP is not only related to the production of new maps but also to the introduction of new methods for the use of maps by policymakers. In many cases, it is possible to propose an infinite number of solutions for the visualisation of a given phenomena and the problem is to find efficient methods for the choice of the good map by the final user. Our group has an important experiment in this field with the project Hypercarte and related research of other partner teams on dynamic maps and interactive maps.

- **The classical paper Atlas:** The classical cartographic representation of phenomena is based on what we can call a *"paper Atlas"* where a phenomenon is represented by one fixed map with a fixed written comment. With such a solution, the final user is in a relatively passive situation because he/she has no opportunity to modify the proposed map and the associated comment. In some cases the general map of the phenomena is surrounded by smaller maps which give additional information (ex. Symbolic representation of the main spatial structures) but these additional or alternative maps are also fixed and can not be interactively modified. Even if several maps of the same phenomena are proposed (e.g. the alternative maps of GDP/person presented in Annex of the SIR of ESPON 3.1) they are all analysed in a sequential way without the opportunity of navigation from one representation to another one.
- **The hypertext Atlas:** This solution is a simple but powerful improvement over the previous solution, which can be easily developed on CD-ROM or the Web. As in the previous case, the maps are fixed (no possibility of modification of the picture) but they can be consulted in different ways, according to a network of link. It is therefore possible to propose a unique comment of the phenomena which allows different paths of reading the maps proposed in the Atlas.
- **The interactive Atlas:** This solution which has been made possible by the development of new languages like Flash or SVG give to the reader the opportunity to modify the representation of the target phenomena. It is for example possible to change the statistical breakdowns or the cartographical patterns of the map and to obtain direct information of specific territorial units by simple clicking on the map.

With this approach, it is possible to propose a reference map but to let the reader have the opportunity of producing alternative maps.

- **The Hyperatlas:** This solution is an extension of the previous one where the reader can not only modify the representation of the maps but strongly modify the result by a full re-computation of the results at another scale of analysis or with other assumptions. It implies not only a system of visualisation (like Flash or SVG) but also an online system of statistical analysis and computation which allows the calculation of new values according to user's requirements. The "ESPON-Hyperatlas" proposed in ESPON 3.1 is a good example of such approach where the reader receive a set of coherent maps but can change at any moment the variables, the reference area, the basic territorial units, … This last function is especially useful in the case of MAUP because it make possible the choice between various solutions of NUTS mixtures. Each "formula" of mixture is stored as an aggregation key of basic territorial units and the final user is able to choose the territorial division which is the best in his/her opinion. For example, we can imagine that some users will prefer a breakdown with strong political constraints (full respect for official units) while another user will prefer a breakdown with strong scientific constraint (maximum functional homogeneity). With such a tool, it is not a problem to satisfy simultaneously the various requests of users.
- **Scale animated maps:** In the particular case of parametric smoothing methods where the number of solution is virtually infinite, it is possible to introduce another possibility of representation which is a translation to scale of the animated maps used for the representation of a time evolution. Instead of having an evolution of the spatial distribution from time 0 to time N, it is possible to introduce a progressive generalisation of the distribution from scale 1 to scale N. The user can choose between various type of presentation of the animation, either as a diorama (with discrete jump from one scale to another) or as a film (with continuous transformation of the map according to scale generalisation). Examples of this are presented on the Hypercarte website (http://www.parisgeo.cnrs.fr/cg/hyperc/index.htm).
- **Expected outputs :** It is not possible to develop specific software for all of the previous solutions in the framework of project ESPON 3.4.3 (which is an exploratory study) but it is certainly necessary to give sample of each family of solution during the test phase of MAUP solutions by policymakers.

WP 3.5 Functional distances (CESA)

We intend to use the distance matrix between NUTS 3 regions elaborated by TPG 1.2.1 in order to define functional neighbourhoods based on realistic distances (e.g. road time) and not only on geometrical distance. This is for example necessary for the project of realisation of "Functional NUTS2/NUTS3" described in WP 3.2. But we need also new distance matrix between NUTS centre and grid points, in order to realise smoothed map based on time distance, like "Unemployment rate in a neighbourhood of 2 hours" described in WP. 3.3.

WP 3.6 Collection of revised ESPON maps (RIATE)

A collection of revised ESPON Maps will be presented as general output of WP.3 that will be presented in the draft final report for evaluation by policymakers. This collection of maps will be presented both on paper version and website (or CD-Rom) in order to have opportunities of interactive consultation of Maps developed in WP. 3.5

2.4 WP 4: VALIDATION OF RESULTS

Objective: The objective of this workpackage is to summarise the results obtained in work package 2 and work package 3, including feed back from policy-makers (ESPON MC) and European statistical agencies (EEA, Eurostat). Therefore, we propose to deliver a draft final report at M9 in order to have time to obtain feed-back for the final report to be delivered at M12.

Teams involved: GEOGRAPHIE-CITES, RIATE, All

Organisation:

WP 4.1 Feed backs from statistical agencies (Géographie-cités, UMEA, NCG, BBR)

WP 4.2 Feed backs from ESPON Monitoring Comitee (RIATE, IGEAT, ID-IMAG)

WP 4.3 Experiment on cartographic perception (CESA)

WP 4.4 Final Report (GEOGRAPHIE-CITES+All)

Deliverables & Timetable:

Code	Description	Responsible	Date
D.4.a	Delivery of draft final report	RIATE	April 2006
D.4.b	Organisation of feed back session	RIATE	May 2006
D.4.c	Delivery of Final Report	GEOGRAPHIE-CITES, All	June 2006

Precise description of work realised in WP 4

WP 4.1 Feed backs from statistical agencies (Géographie-cités, UMEA, NCG, BBR)

It is of crucial importance that the solutions proposed by ESPON Project 3.4.3 to the MAUP would be presented and validated by the European Statistical Agencies (EEA, Eurostat), Commission (DG Regio) and associated organisations (OECD, JRC) and the umbrella organisation INSPIRE. Indeed, a solution which would be elaborated by the ESPON Program without agreement of this agencies has very few hope to be useful in a medium or long term perspective, because ESPON is not able to develop isolated databases without a strong cooperation with these agencies.

Therefore, when our draft interim report will be achieved in March 2006, we propose to send a copy to all above mentioned institution and to invite them to send reactions and to join the discussion of the results during a specific session of the ESPON meeting of May 2006 (see. above).

We have yet elaborated a list of contact person in each of this organisation with which we will have regular contact during the elaboration of project ESPON 3.4.3.

- EEA : Mr Jean-Louis Weber (jean-louis.weber@eea.eu.int)
- EUROSTA : Mr Daniele Rizzi (daniele.rizzi@cec.eu.int)
- JRC : Mr Alessandro Annoni (alessandro.annoni@jrc.it)
- DG REGIO : Mr Hugo Poellman (hugo.poelman@cec.eu.int)
- OECD : Mr Mario Pezzini (mario.pezzini@oecd.org)

WP 4.2 Feed backs from ESPON Monitoring Committee and ECP network (RIATE, IGEAT, CESA, ID-IMAG)

The second and crucial step of validation of the results of project 3.4.3 is the verification that solutions proposed to the MAUP are politically relevant. As in the case of statistical agencies (see. WP 4.1) we will send in March 2006 our draft interim report to all members of the ESPON MC and all ESPON Contact Point, in order to obtain reactions that will be discussed in the specific session of the ESPON Meeting of May 2006. In order to prepare this specific session of May 2006, we will elaborate with the ESPON CU a specific survey in order to obtain a global view of the political evaluation of solutions proposed to the MAUP. Each representative of MC or ECP will be asked to evaluate the solutions (a) from a general point of view and (b) from a national point of view. We can indeed estimate that, in some case, the general principle of solution is accepted but not the specific application on a national territory. For example, the state X*** can agree to the general principle of “Functional NUTS2-3” regions but disagree to the delimitation of regions proposed for his own national territory. Or the state Y*** can agree to the general idea of a “Smoothed map of Unemployment based on time distance” but not to the specific span of 2 hours.

WP 4.3 Evaluation of cartographic perception (CESA)

As a complement to the previous feed-backs from statistical agencies and policy makers, we propose to introduce an innovative experiment on the perception of maps which would be realised by the expert team CESA (Tours). Kamal Serrhini has developed, under the direction of Philippe Mathis, a method for map testing which use a tool called "**occulographe**" which is generally used in ophthalmology. This tool register the movement of the eye of one person and help to display the path followed by the observer of a picture or, in present case, a map. This methodology has been used in marketing but can be transposed to the evaluation of map produced by researcher and used by policy makers. It is an objective way to evaluate how the maps produced by ESPON are read, interpreted, understood and memorised by final users which are not necessary specialist from graphic semiology. In other word, we intend to test which message is really transmitted by researchers to policy makers in the framework of the ESPON program …

We propose to experiment this method during the ESPON meeting of may 2006 at the moment where the set of new maps realised by ESPON 3.4.3 will be commented and discussed. We will select a limited set of maps of various type (smoothed, territorial, …) and examine how a selected sample of users proceed when he/she explore this maps. The conclusions of this experiments will be presented in the final report.

WP 4.4 : Final Report (GEOGRAPHIE-CITES + RIATE +All)

The Final Report will take into account all feed backs developed above (WP.1, WP.2, WP.3) and include related correction in the initial version delivered in March 2006. It will also develop specific recommendations for future ESPON II. It will also introduce a specific annex called "Dictionary of tools" which will explain in details the "know-how" of the best solutions which will have been proposed by scientists and validated by policy makers. This dictionary of tools could be completed by a CD-Rom where future users will find the datasets and program used for the realisation of maps presented in the final report of ESPON 3.4.3.

2.5 Working Group and Experts

UMR 8504 GEOGRAPHIE-CITES

1. Name and address of your organisation;
CNRS (Centre National de la Recherche Scientifique) – UMR 8504 GEOGRAPHIE-CITES
13 rue du Four
75006 PARIS – France
Tel 00 33 1 40 46 40 00
Fax 00 33 1 40 46 40 09
Web http://www.parisgeo.cnrs.fr

2. List of the persons potentially involved in the project with a short CV and a short list of relevant publications;

Claude GRASLAND (see. RIATE)
Léna SANDERS, Senior Researcher (short CV attached)
Hélène MATHIAN, Research Engineer (short CV attached)
Maher BEN REBAH, Ph D

3. Year of foundation and type of organisation;
1939
Public research institute.

4. Proof of your technical capacity, description of activities and skills (IT, languages);

Cartography
Human Geography
Spatial Analysis
Statistical analysis
Operating systems: Windows
Cartographic software: Arcview, Mapinfo, Surfer, Philcarto
Statistical software: SAS, XLSTAT.
Languages: SAS-IML, DELPHI (Pascal), VB

5. Intentions for the composition of the team including relevant experience, qualification and university degrees envisaged of the persons involved;

See CVs attached

6. Scientific know how in the field of activity covered by the service requested;

Statistical Analysis

Spatial Analysis
MAUP
Smoothing methods
Animated Cartography & Dynamic Maps

7. Which other ESPON group you participate;
- as main partner in ESPON 1.1.1 "The role, specific situation and potentials of urban areas as nodes of polycentric development";
ESPON 2.3.2 "Governance of Territorial and Urban Policies from EU to local level (2004-2006)" and
ESPON 3.4.1 "Europe in the World"

- as consultative partner in ESPON 3.1 "Integrated Tools for European development" and ESPON 3.2 "Spatial scenarios and orientation in relation to the ESDP and EU cohesion policy"

8. Name and phone number of the person in charge of the financial management of this project.
Le Délégué Régional Tony ROULOT
27 rue Paul Bert
94204 IVRY CEDEX
FRANCE
Tel 00 33 1 49 60 40 00
Fax 00 33 1 45 15 01 66

9. The logo of your organisation.

IGEAT - Institut de Gestion de l'Environnement et d'Aménagement du Territoire

Legal status:
IGEAT is an institute of the Free University of Brussels (ULB) and as such has the status of a department ("faculté") of the University.

Short general description of the service provider:
Founded in 1993 within the Free University of Brussels (ULB), the Institut de Gestion de l'Environnement et d'Aménagement du Territoire (IGEAT) is an interdisciplinary education and applied research institute oriented towards consultancy and decision-aid - for both public and private contractors - in the fields of environment, town and land planning, local development as well as tourism. The Institute is dedicated to the promotion of an effective multidisciplinary approach in all the above fields. Steadily expanding since its creation, the IGEAT is composed today of a core of 60 researchers (from PhD-candidates to senior professors) from various disciplines in applied, natural, economic and social sciences. The Institute works on a wide series of research projects using different disciplinary perspectives at different scales from local authorities to the European level. It is composed of 10 thematic research units:

1. The Land Planning, Environment and Transport Unit
2. The Centre for Studies on Sustainable Development
3. The Architectural Heritage Unit
4. The Environmental Law Unit
5. The Geographical Information System and Remote Sensing Unit
6. The Tourism Management Unit
7. The Local Development Unit
8. The Ecotoxicological Studies on Pollution, Health and Impacts Unit
9. The Applied Geography and Geomarketing Unit
10. The Institute is also active in teaching and offers three degrees, one graduate (tourism management) and two post-graduate (environmental management and local development).

The IGEAT - with its large interdisciplinary team of different scientific orientations (geographers, agronomists, economists, biologists, historians, etc.) - has always considered that a real comprehension of spatial phenomena can only develop out of an integrated approach of indicators concerning spatial planning, regional and local development, regional economy, and the environment, all of which are fields represented in the IGEAT.

The Institute has acquired high expertise in the management of large socio-economic databases: for at least 15 years, it has collected large amounts of demographic and economic, but also environmental data for analytic reports and atlases at regional, federal and European scale.

Legal position

Name of legally responsible person:
Pierre de Maret
Recteur de l'Université Libre de Bruxelles

Economic and financial capacity
General Information (main functions, total funding, sources of funding, etc.)): University: Main funding: Ministère de la Communauté française de Belgique Institute: Main funding: Université Libre de Bruxelles; sources of other funding: federal government, regional governments, EU, private sector, associations…

Technical Description of Partner

Name (of the institution)	Institut de Gestion de l'Environnement et d'Aménagement du Territoire Université Libre de Bruxelles
Date of founding of the research body	1993 based on pre-existing research units.
Enrolment in companies register (if applicable)	n.a.
VAT number	no
Address	C.P. 246 Boulevard du Triomphe B - 1050 Bruxelles BELGIUM Tel.: +32-2-650.50.72 Fax: +32-2-650.50.92
Annual turn over (in €)	148.883.088 Euros (2002)
Average annual staff and the number of management staff over the past three years	60 researchers from PhD students to senior professors 4 management staff
Day rate of staff involved (actual salary costs, including social security and taxes, not lump sum consultancy fees)	300€/day
VAT rate	n.a.
Knowledge of languages, in particular the English language (writing/reading/speaking, please use scale 1 - 5, where 1 = poor and 5 = excellent)	French: 5 / 5 / 5 English 5 / 5 / 5 German 5 / 5 / 5 Dutch 2 / 4 / 3 Spanish 2 / 4 / 3
A description of technical and IT equipment, with a comprehensive list of all the available software (specifying the version) to be used	1 PC/ working place, MS Windows, MS Office, SPSS, Arc view-GIS, Arcinfo, GRASS GIS, IDRISI, GNU/Linux, PostgreSQL, R, access to University mainframe systems running UNIX with SAS, Informix, etc

Description of the **provisional** number of persons and type of expertise which the partner will assign	Christian Vandermotten, Docteur en Géographie, Licencié en Urbanisme Co-Head of Unit "Applied Geography and Geomarketing" Gilles Van Hamme, Researcher Moritz Lennert, Researcher Please find CV in: annex: CV-ULB-1-C-Vandermotten.doc, CV-ULB-2-Lennert.doc, CV-ULB-3-Van-Hamme.doc

A list of the major research and other research-related activities carries out over the past three years relevant to the content of the contract, with the date, and the name of the client (public or private sector)	Please see below.
Other experiences in international consortia and networks	Please see below.

Technical capacity

Proof of the technical capability: Projects elaborated for international, European, national, regional and/or local authorities since 1999 as well as information interesting from the view point of tenderer.

The IGEAT's main activity in terms of research is consultancy work for authorities at all scales, from local to European and it has thus been able to accumulate experience in project management and research coordination, including in an international, i.e. intercultural setting. On the European level, the Institute

- is ESPON Contact Point for Belgium
- is Interreg3B NWE/ENO Contact Point for the Walloon and Brussels Regions

The IGEAT has participated and still participates in several European networks. Currently or recently, the Institute:

- is Lead Partner in the ESPON 3.2 "Spatial scenarios and orientations in relation to the ESDP and EU Cohesion Policy" project
- participates in ESPON projects 1.1.4, 2.3.2 and 3.4.1
- participates in a study on "Territorial Cooperation and transnational cooperation programmes within Structural Funds" for DG Regio
- prepared, in collaboration with the Catholic university of Leuven (KUL), the Belgian ESPON Data Navigator;
- participates in the POLYNET: Sustainable Management of European Polycentric Mega-City Regions, INTERREG IIIB NWE programme;
- actively participated in the ``Competitive Metropolises" (COMET) Fifth Framework Programme research project, being responsible for WP8;
- was part of the Rural and Urban Research in Europe (RURE) network created by the European Science Foundation; some of the research concerning economic and population geography this project continued until recently in the Migration research in Europe (MIRE) project of which the IGEAT was Lead Partner;

- coordinated SPACE-Euroregion;
- participated in the Group for European Metropolitan Areas Comparative Analysis (GEMACA);
- participated in GEMACA II;
- has conducted a long comparative study of European cities in collaboration with over 30 universities, research institutes and urban planning agencies across Europe. The result of this study is the publication ``Villes d'Europe. Cartographie comparative".
- The Institute is frequently solicited by the Belgian federal government for consultancy work. On regional level, the IGEAT regularly works for the Brussels regional government and is part of the Permanent Conference on Territorial Development (CPDT) created by the Walloon Region and thus participates in many studies generating multiple databases, indicators and publications.
- participation in the European project SOS.

In December 2001, the IGEAT organised a colloquium on "The Sustainable Development of Territories" which lead to the publication of the book "Le développement durable des territories".

Within the Walloon Region Permanent Conference on Territorial Development (CPDT) the Institute plays an important role, heading several of the working groups.

The IGEAT has organised several international (and national) colloquia on urban economic development, on sustainable development, on local development in Walloonia and on the role of geography in society and recent mutations in spatial organisation of world regions. On the local level, on behalf of the Brussels Regional Government, it has recently organised a brain storming session concerning a local urban development project, involving about 100 participants from all parts of society.

Publications:

Vandermotten C. et P. Marissal avec la collaboration de A. Dubreucq et J.C. Defraigne (2003), La production des espaces économiques, tome 2, Editions de l'Université de Bruxelles, 295 p.

Vandermotten C. et Gh. Geron ed. (2002), Le développement durable des territoires, Editions de l'Université de Bruxelles, 231 p.

Vandermotten C., F. Vermoesen, W. De Lannoy, S. De Corte (1999), Villes d'Europe. Atlas comparatif, Bulletin trimestriel du Crédit Communal de Belgique, 53, 1-2, 207-208, 408 p.

Vandermotten C. et P. Marissal (1998), La production des espaces économiques, tome 1, Editions de l'Université de Bruxelles, 323 p.

Vandermotten C., A. Colard, P. Marissal et G. Van Hamme (1995), Atlas Economique de la Belgique, Bruxelles, Editions de l'Université de Bruxelles, 165pp.

Research reports:

Vandermotten C., G. Van Hamme, P.Medina Lockhart, B. Wayens et M. Roelandts avec la collaboration de A. Montanari (Pescara), T. Champion (Newcastle), A. Garcia Ballesteros (Madrid), W. Mathiessen (Copenhague), W. Matznetter (Vienne), H.H. Blotevogel (Duisburg) (2002), Migrations in the European Union : from the last decades to the new trends. Final report of the research « Interregional migrations in Europe - Migrations interrégionales en Europe (MIRE), European Commission, G.D. Employment and Social Affairs.

Vandermotten C., V. Biot, J. Charles, A. Colard, L. De Borman, M. Lennert, M.E. Ronveaux, G. Van Hamme, Y. Vekemans et du BRAT, de grand Lille Créativité et de Roger Tym &

Partners (2002), L'Eurorégion. Un espace de collaboration au coeur de l'Europe du Nord-Ouest, Space. Aménagement du territoire, Programme Interreg IIC.
Vandermotten C., H. Barthe-Batsalle, V. Biot, L. de Boorman, C. Neuray, M.E. Ronvaux, G. Van Hamme, Y. Vekemans, J. Charles, O. Decocq, C. Patris, V. Rousseaux (2002), Repères pour une dynamique territoriale en Wallonie. Atlas, Ministère de la Région Wallonne, Conférence Permanente du Développement Territorial, 181 pp.
III.2.1.3.a) Vandermotten C. et A. Colard ed. (1999), Schéma d'Objectifs Stratégiques. Eurorégion, CPDT et EU DG XVI.
Vandermotten C.. C. Kesteloot, A. De Turck, P. Marissal & G. Van Hamme (1999), Structures sociales et quartiers en difficulté dans les régions urbaines belges. Sociale structuren en buurten in moeilijkheden in de Belgische stadsgewesten, KULeuven et ULB, Politique des grandes villes, 108 pp.
Vandermotten C., A. Colard, P. Marissal & G. Van Hamme (1997), Emploi et structures socio-économiques régionales, Monographie n°6 du Recensement Général de la Population et des Logements au 1er mars 1991, Bruxelles, INS et SSTC, 190 p.

Articles and chapters :

Vandermotten C. (2003), Le polycentrisme dans une perspective historique, in R. Allain, G. Baudelle et C. Guy (éds.), Le polycentrisme, un projet pour l'Europe, Presses Universitaires de Rennes, pp. 17-28.
Vandermotten C. et P. Medina Lockhart (2000), Géographie électorale de l'Europe, chap. 11 in G. Grunberg, P. Perrineau & C. Ysmal (éds.), Le vote des Quinze. Les élections européennes du 13 juin 1999, Paris, Presses de Science Po, pp. 245-293.
Vandermotten C. et Pierre Marissal (2000), Une nouvelle typologie économique des régions européennes, L'Espace géographique, 4, pp. 289-300.

NCG - The National Centre for Geocomputation

1. Name and address of your organisation;
The National Centre for Geocomputation
John Hume Building
National University of Ireland, Maynooth
Maynooth
Co. Kildare
IRELAND

2. List of the persons potentially involved in the project with a short CV and a short list of relevant publications;
A. Stewart Fotheringham (short CV attached)
Martin Charlton (short CV attached)
Stamatis Kalogirou (short CV attached)

3. Year of foundation and type of organisation;
2003
Research Unit funded by Science Foundation Ireland to undertake research into GIS and Geocomputation

4. Proof of your technical capacity, description of activities and skills (IT, languages);
Statistical analysis
Mathematical modelling of spatial processes
GIS
Geocomputation
Software development
Operating systems: Windows; UNIX
Languages: FORTRAN; UNIX; Visual Basic

5. Intentions for the composition of the team including relevant experience, qualification and university degrees envisaged of the persons involved;
See CVs attached

6. Scientific know how in the field of activity covered by the service requested;
Statistical analysis of spatial data
MAUP
Visualisation and graphics
GIS

7. Which other ESPON group you participate;
None

8. Name and phone number of the person in charge of the financial management of this project.
Ann-Marie Burke, Senior Executive Assistant
National Centre for Geocomputation

John Hume Building
National University of Ireland, Maynooth
Maynooth
Co. Kildare
IRELAND
Tel: x-353-1-708-6455

9. The logo of your organisation.

University of Umeå / SMC

- **University of Umeå /SMC (SWE).** SMC is an external research unit within the Department of Social and Economic Geography, Umeå University, whose main field of action is to study the interactions between human activities and the environment. SMC is mainly funded by the Goal 1 project SEDEN together with contributions from the County Council of Norrbotten, the Ministry of Education, Research and Culture and the Ministry of Industry, Employment and Communication.

- For some years, longitudinal individual information with high temporal and spatial resolution has been made available for research in Sweden. SMC/Umeå University has bought individual annual register information from Statistics Sweden for the years 1985-2002. This research database, ASTRID, contains around hundred attributes such as age, sex, family relations, education, incomes and benefits, immigration origin and year, land use and value of owned land properties, place of living and work with 100 meters resolution etc for each person that lived in Sweden during this period. The purpose of the database, and the reason for the permission to use the data, is for developing spatial micro-simulation models. SMC has built a model that can simulate the life of the whole Swedish population on individual level. The underlying work i.e. defining the modules, determine the order of events, estimating the equations, and producing aggregated information for look-up tables, was all done exploiting the database. Contemporaneously, this work has provided an excellent competence for analysing data at both micro and macro levels.

- Due to access to the ASTRID database, we can avoid much of the Modifiable Area Unit Problem. However, we can also avoid some of the more general problem behind MAUP: For what kind of research problems does aggregation (not only spatial) prior to analysis bias results? Of course, micro-results are biased or non-existent without individual data – but is that also the case for all kinds of aggregated results? Are all demographic and socioeconomic problems equally sensitive to early aggregation? One hypothesis is that i.e. simple regional demographic projections and descriptions not necessarily become better based on individual information as compared to regionally disaggregated tables.

- In this case, the main uncertainties are anyway not buried in observable individual attributes but rather in changes in attitudes and regional economic performance. Phenomena where scale and heterogeneity in the process matters more for the outcome might give other results. Unemployment is the result of matching local supply and demand within a very diversified labour market. The detailed individual composition of competences and requirements should matter.

- We propose to investigate three examples, the distribution of the population (regional and local), incomes, and unemployment, respectively. Indicators like percentage 65+, mean age, cross-sectional fertility, income level, income distribution, unemployment level and distribution etc. are constructed. Results with measurements on individual level are compared to results based on data aggregated to administrative regions like, for instance, municipality (NUTS5) and county (NUTS3). We also compute measures based on different ranges centred around individual 100 meter squares, like ranges

with a radius of 500 meters, 5 km and 50 km. The results will be analyzed with various statistical methods and visualized on maps. This experiment will give information whether or not the use of administrative regions distort results compared to using ranges on corresponding spatial scales centred around the acting individuals themselves. Furthermore, it will demonstrate whether a prospective distortion is similar in character for the sparsely populated area of northern Sweden compared to the more densely populated southern part of the country.

- The research group for this project will include Professor Einar Holm, Dr. Kirsten Holme and Dr. Magnus Strömgren. Einar Holm has during more than three decades worked with a variety of modelling and simulation projects of which the main part has been concerned with micro-simulation. The data that has been used for the models includes both highly aggregated data and micro data. The aims of the projects have ranged from scientific purposes to assisting in policy making. Kirsten Holme is experienced in handling and analysing data using GIS and large databases with longitudinal demographic data, and has evaluated modules and implemented data and functions in simulation models. Magnus Strömgren has carried out research concerning geographical diffusion of attitudes and is experienced in GIS, database systems, simulation models and statistical analyses.

  The responsible of the financial management of this project is **Lotta Brännlund**, economy administrator at the Department of Social and Economic Geography, Umeå University, S-901 87 Umeå, Sweden
  Tel +46 (0)90 786 71 52
  Fax +46 (0)90 786 63 59
  E-mail lotta.brannlund@geography.umu.se

- The responsible of participation in Project 3.4.3 is
  Professor **Einar Holm**, Department of Social and Economic Geography, Umeå University, S-901 87 Umeå, Sweden
  Tel +46 (0)90 786 57 29
  Fax +46 (0)90 786 63 59
  E-mail Einar.holm@geography.umu.se

3 ANNEXES

3.1 Experiments on the MAUP developed in the SPESP

Author : Claude GRASLAND (1998)
Source : SPESP, Work Package 1.4 “Spatial integration”

The aim of this working paper is to demonstrate the interest of the Hypercarte project through the application of the methodology of multiscalar smoothing methods to a particular problem : *the determination of subvention granted to territorial area according to selected criteria*. As an example, we discuss the possible solutions for a fictive example called "**Objective 13-bis**", applied to the case of Belgium territory.

3.1.1.1 "OBJECTIVE 13-BIS" : A TERRITORIAL APPROACH

Imagine that an international institution has decided in 1991 *to grant money to area where a decrease of population has been observed during the last 13 years (1978-1991)*. This "objective 13-bis" can be established on the basis of existing territorial division but the total amount of subvention obtained by Belgium will be different according to the choose of the level of territorial organisation used for the computation of population decrease. The results will also be different according to the nature of the subvention (equal for each territorial unit or proportional to their population in 1991).

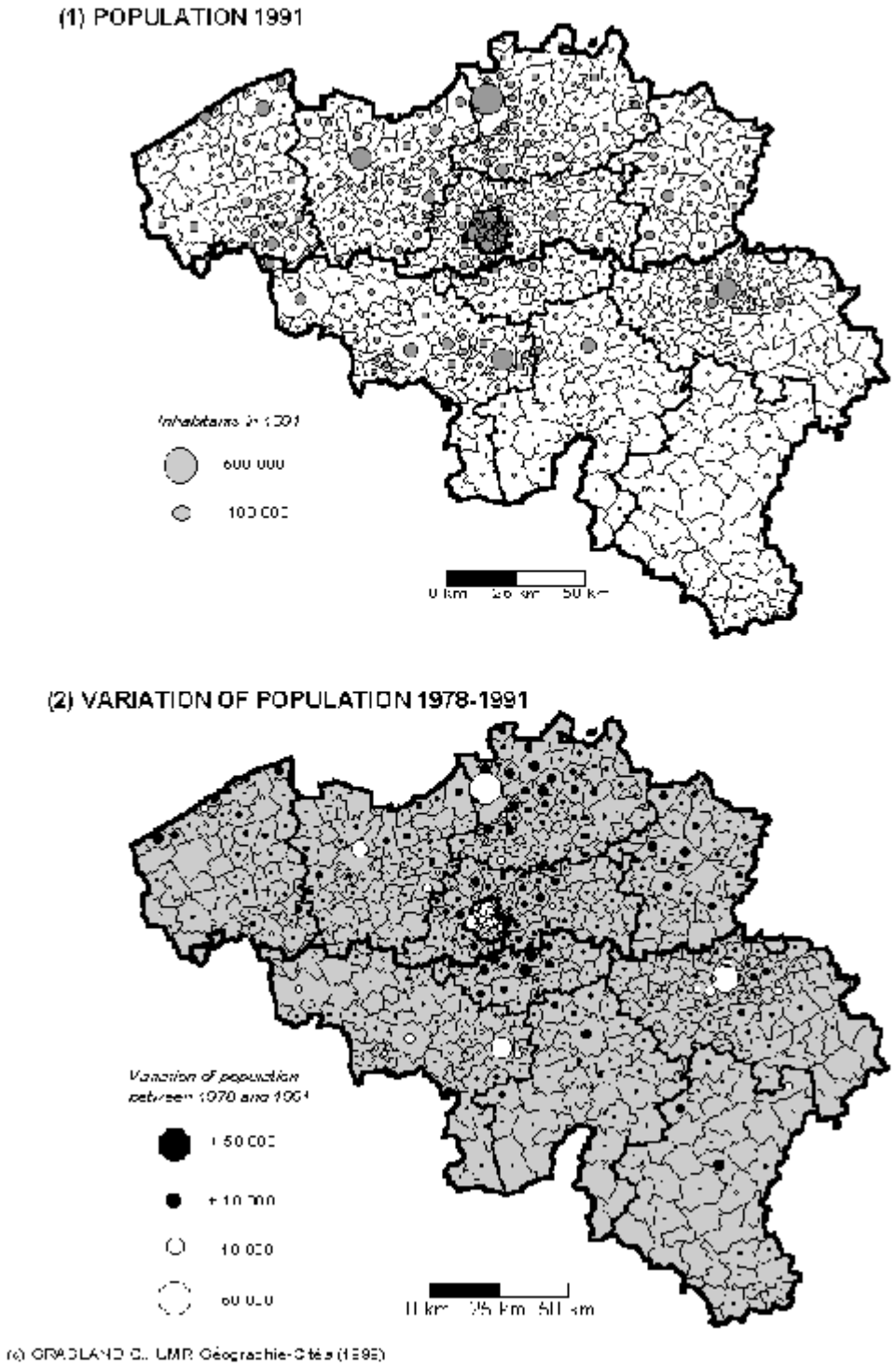
The example of Belgium is very interesting because the increase of population during the period 1978-1991 was slightly positive but very near from 0. Thus, a slow change in territorial divisions can produce dramatic change in the amount of subvention.

- At the most local level (*589 communes*), it is possible to observe a decrease of population in 165 communes with a related population of 4540000 inhabitants. Accordingly 28% of the communes and 46% of the population could be concerned by the "Objective 13 bis".
- At the level of the *43 arrondissements*, the results are more or less the same : 13 arrondissements (30%) and 4046000 inhabitants (41%) would be concerned by the objective. But their location is rather different and some communes will gain or lose subventions according to their location in increasing or decreasing arrondissements, whatever their local situation of population variation.
- At the level of the *11 provinces*, the results are not so interesting for Belgium because only 3 territorial units (27%) and 3240000 inhabitants (32%) are now concerned by the objective. And the situation could be worth if Belgium has maintained the older division in *9 provinces* because in this case they would be no subventions for the decreasing unit of Brussels, aggregated with increasing provinces of north and south-Brabant. At the level of the 9 former provinces, only 23% of the inhabitants would be concerned by the objective.

- At the level of the *3 regions*, only Brussel is concerned by the objective (10% of the inhabitants). But if Brussels was agregated with Wallonia, the new region would be decreasing and 42% of the inhabitants would be concerned by the objective. In reverse case (Brussels aggregated with Flanders), nobody in Belgium would be concerned by the objective.
- Finally, if Belgium is considered as a single territorial unit (*1 state*), the increase of population is slightly positive (+2%) and the whole state is out of the objective 13-bis.

This classical demonstration shows the dramatic influence of strategic and political choices on the results of territorial planification and lead necessary to the question : is it possible to propose another approach ?

Figure 1 Variation of population in Belgium at level Nuts 5 (1978-1991)

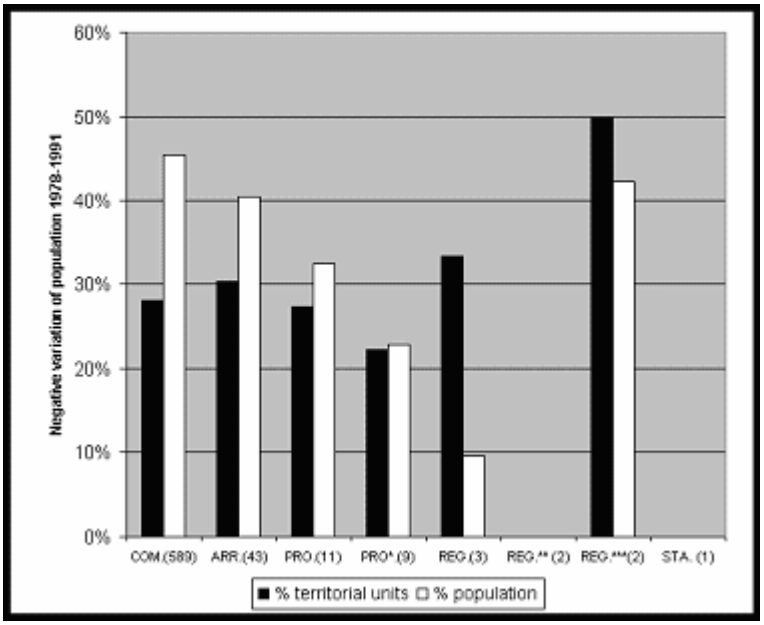


(c) GRASLAND C., UMR Géographie-Cités (1995)

Figure 2 Results of Objective 13-bis according to various territorial divisions

Territorial division	Administrative result			Population result	
	n	units	%	inhabit.	%
Communes	589	165	28%	4540635	46%
Arrondissements	43	13	30%	4046031	41%
Provinces	11	3	27%	3241356	32%
Provinces *	9	2	22%	2281032	23%
Regions	3	1	33%	960324	10%
Regions**	2	0	0%	0	0%
Regions ***	2	1	50%	4219119	42%
State	1	0	0%	0	0%

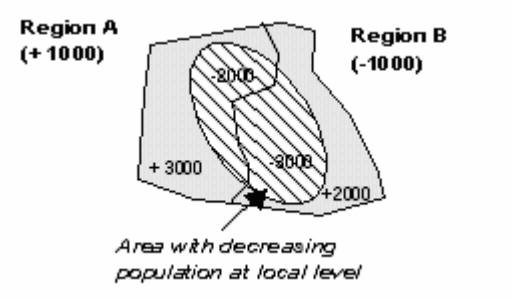
* : former division in 9 provinces (Bruxelles + North-Brabant + South Brabant)
** : Bruxelles aggregated with Flanders
*** : Bruxelles aggregated with Wallonia



3.1.1.2 "OBJECTIVE 13-BIS" : A MULTISCALAR SPATIAL APPROACH

Another approach of the problem is to answer to the question *: "Why do we give money to people or territory"* or *"At which scale of neighbourhood is it justified to provide subvention to inhabitants located in regions with decreasing population"*. In Belgium as in the rest of Europe, the centers of urban area has a negative variation of population but are surrounded by suburban areas with increasing population. The decrease of urban centers is only the consequence of a relocation of inhabitants and does not necessary imply a decrease of population at the level of the whole functional urban areas. If the purprose of "Objective 13-bis" is to help people located in *regions* with negative increase of population, it is obvious that the level of communes is not adapted and that it is necessary to use Nuts2 or Nuts 3 levels for the attribution of subvention. But if the purprose of "Objective 13-bis" is to help territorial communities with fiscal problems (decrease of ressources related to taxes in central urban areas), the level of communes could be also justified.

But whatever the solution adopted, the choose of territorial units has a tendancy to produce social and spatial inequities related to discontinuities in the attribution of subvention. If a continuous area of decreasing population is located on both side of an aministrative boundary, the attribution of subvention can be granted on on side on the boundary and refused on the other side according to the overall variation of population on the territorial units located on each side of the boundary :



The use of a multiscalar smoothing method appears very interesting in this framework because the situation of each place can be evaluated in a continuous approach based on an homogeneous criterium of neighbourhood based on a function of distance around each commune (**Figure 3**) . The experiments realised on Belgium with gaussian neighbourhood at different scales indicates clearly the dramatic variation of the criterium according to the span of neighbourhood which is used (**Figure 4**). We can observe that the amount of subvention is not simply decreasing with the size of neighbourhood and that an "optimal solution" (maximisation of subvention) is obtained for a scale parameter equal to 20 km (44% of the communes and 57% of the inhabitants involved in decreasing area). With a lower scale parameter we observe a decrease of subvention (e.g. 31% of communes and 49% of population with scale parameter equal to 5 km). With a greater scale parameter we observe also a decrease and the amount of subvention is equal to 0 for each scale parameter greater or equal to 85 km. A precise analysis of the maps related to each scale parameter (**Figure 4**) indicate important variations in the territorial location of subvention and provide solutions for an "optimal territorial division" according to political or strategic decisions. Shortly said, those maps are probably one of the best tool for a state which decide to maximise its benefits and/or to proceed to an equitable distribution of subventions on its whole territory (e.g. computation of the amount of subventions obtained by Flanders and Wallonia according to the scale parameter).

Figure 3 Variation of population in Belgium (1978-1991) according to different scales of spatial neighbourhood.

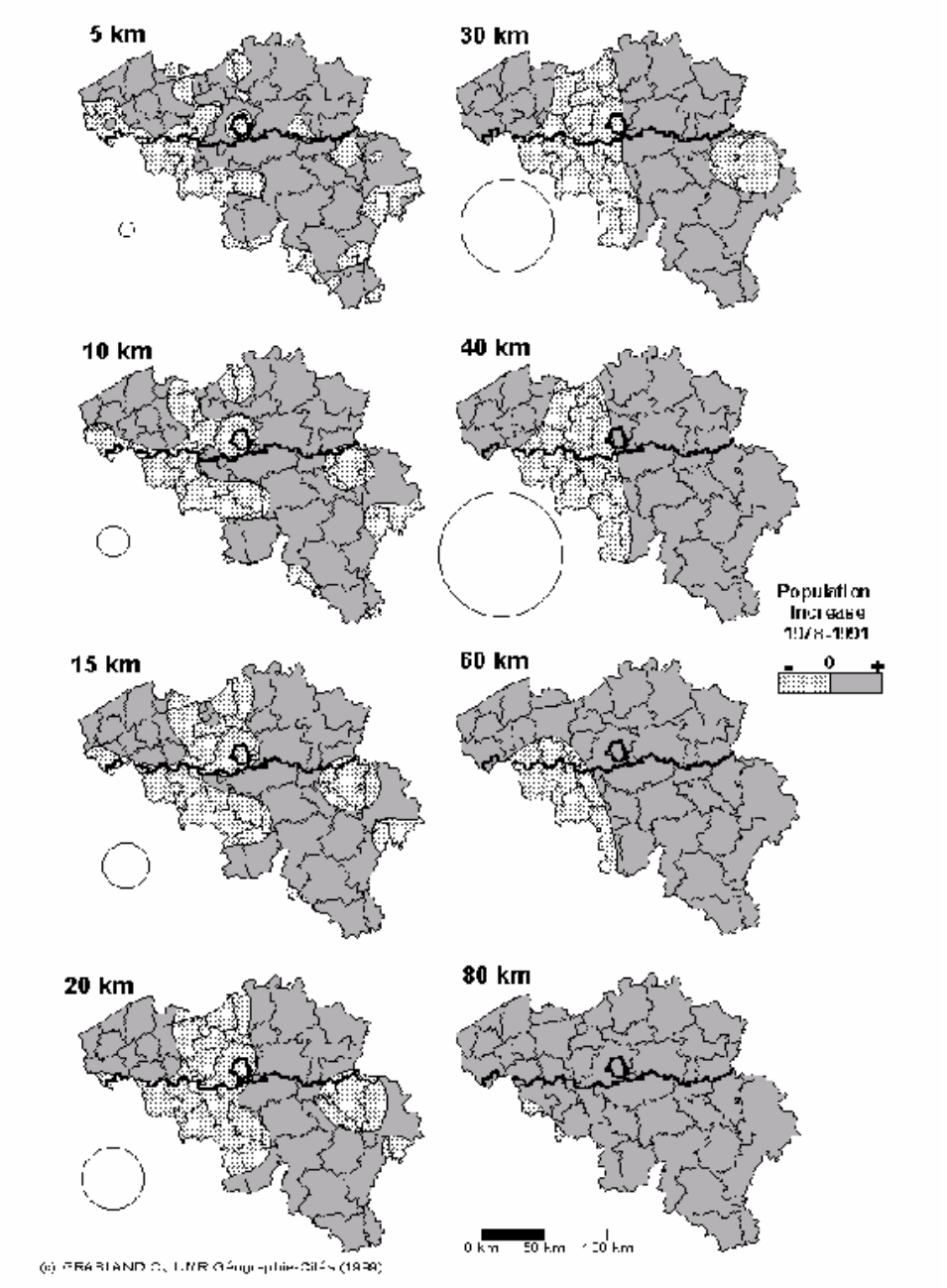
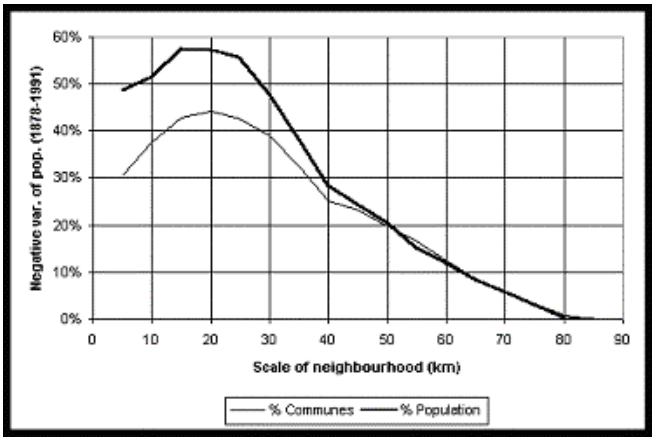


Figure 4 Results of Objective 13-bis according to various scales of spatial neighbourhood

Spatial Neighbourhood	Administrative result		Population result	
(gaussian function)	communes	%	inhabit.	%
0 km (communes)	165	28%	4540635	46%
5 km	180	31%	4856867	49%
10 km	221	38%	5140270	52%
15 km	252	43%	5732949	57%
20 km	260	44%	5697571	57%
25 km	251	43%	5551928	56%
30 km	229	39%	4776694	48%
35 km	191	32%	3811093	38%
40 km	148	25%	2847600	29%
45 km	137	23%	2415950	24%
50 km	116	20%	2038452	20%
55 km	97	16%	1513407	15%
60 km	73	12%	1176705	12%
65 km	51	9%	822845	8%
70 km	32	5%	566429	6%
75 km	19	3%	298120	3%
80 km	5	1%	32219	0%
85 km	0	0%	0	0%



CONCLUSION

The aim of this working paper is not to criticize actual practices of territorial planning or to proposed a so-called "optimal solution" to the very difficult question of territorial planning and territorial subventions. We simply assume that the solutions to those very difficult questions (which has to take into account many non-scientific parameters) could be ameliorated with new tools of spatial analysis and cartography.

The spatial neighbourhood approach (based on euclidian distance) is only a preliminary approach of the problem which could be improve through the consideration of social neighbourhoods (bases on time, cost or perceived distances). What is important is to identify the time-space budget of people which need subventions and to examine if they are able to find ressources in the territory where they are living.

In the case of unemployement, for example, the question is to define the maximum area where people are able to find a job without beeing oblige to migrate. If we observe that this "job-area" is equal to a radius of 2 hours around the place where they live, the rate of unemployement in a 2 hours neighbourhood is probably the good criterium for the attribution of subventions to area with high unemployement rate …

According to Max Weber, we think that the work of the scientists is not to take decisions in place of policy makers but to help them to decide and to give them a clear conscience of the reasons and consequences of their choices.

3.2 Experiments on the MAUP developed in HYPERCARTE

Author : Claude GRASLAND (March 2000)
Source : Hypercarte Project : http://www.parisgeo.cnrs.fr/cg/hyperc/wp3/wp3.htm

3.2.1.1 INTRODUCTION

The *Modifiable Area Unit Problem* (MAUP) has been recognize since the 1970's as one of the most difficult challenge for geographers, cartographers and spatial analysist. As recognize early by many authors (e.g. S. Oppenshaw), the cartographical pattern of the spatial distribution of variable or the level of correlation between two variables distributed in space can be completely modified according to the level of aggregation of spatial units or more generally the spatial grid used for the collect of spatial information. The MAUP has very deep consequences, from theoretical, methodological and practical points of view and is a major challenge for all researchers or planners using spatial information for statistical or cartographical purproses.

Our purprose in the present paper is not to discuss in details those different problems, neither to propose a review of existing solutions which has been proposed by many authors to face the MAUP's problem. We would just like, through a canonical example (the variation of population at the France-Belgium border), to present a possible direction of research based on multiscalar smoothing methods, derived from a probabilistic reformulation of the concept of population potential. This method which has been developped by the *Hypercarte Research Group* is presented in more details in the Working Paper 1 of the Hypercarte Project and the reader is invited to have a look at this paper for more details on themethod which will be applied in the present study.

3.2.1.2 THE MAUP CHALLENGE

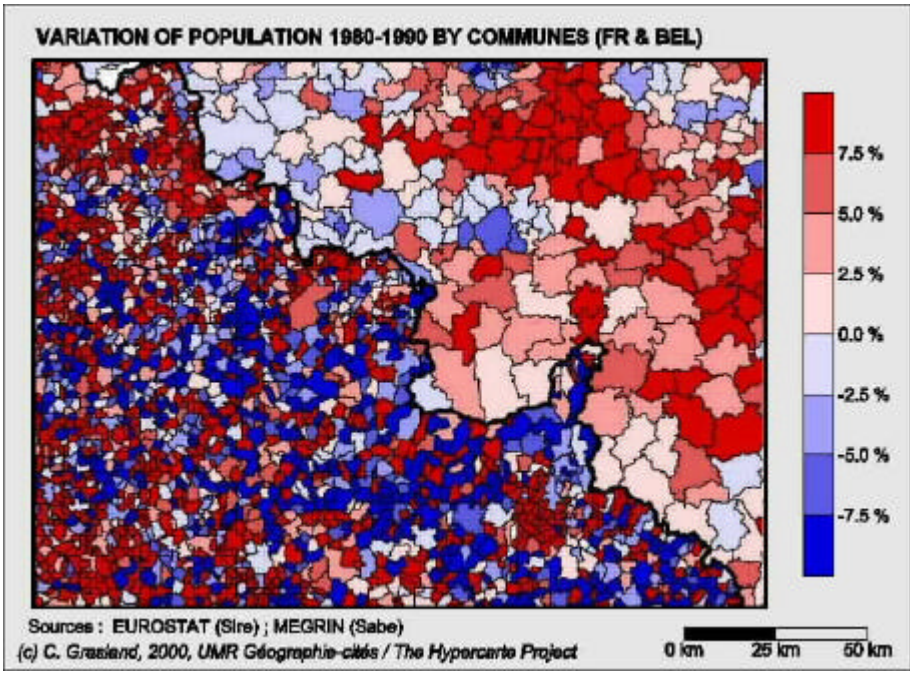
When Eurostat-GISCO published in 1995 a map of the *variation of population in the European Union between 1980 and 1990* at communal level (Nuts 5), the authors of the map was immediatly strongly criticised by most statisticians and cartographers who noticed immediatly the considerable bias induced by the spatial heterogeneity (size, shape) of the Nuts 5 territorial division in Europe.

The authors could be surprised as far as a first map published one year before about the *distribution of population density in 1990* at the same Nuts 5 level did not produce such negative reactions because the phenomena of population density is strongly spatial autocorrelated and the bias induced by the heterogeneity of territorial division was not so evident

But in the case of the variation of population, the bias introduced by territorial division was immediatly perceived by the observers, precisely because the level of spatial autocorrelation is much lower than in previous case. Indeed, the process of suburbanisation introduce around most european towns a circular organisation of the growth rate with generally a negative variation in urban centers, a null or slightly positive variation in near-suburban area, a strong positive variation in far-suburban areas and finally a negative or null variation in deep rural areas. Accordingly, when the size of territorial units was sufficiently small (as in France), the map exhibits very important differences between territorial units (more or less organised in a circular way around city centers) but those differences was eliminated when territorial units was bigger (as in Belgium) and involved urban centers, urban periphery and rural areas in the same territorial division.

The France-Belgium border was the most evident illustration of this bias. As the map used a color scale with deep green for negative values, deep orange for the positive one and light yellow for medium variations, the map exhibited a hard combination of deep green and deep orange on the french territory when the belgium territory was characterised by yellow or light orange and green. As a consequence, the reader perceived a very strong spatial discontinuity along the France-Belgium border (due to the difference of heterogeneity) but it was absolutely impossible to determine if this discontinuity was really related to a change in the level of population variation (*Figure 1*).

Figure 1



- *The area of investigation is a rectangle of 200 km in West-East direction and 150 km in North-South direction. The SW corner is located near Compiègne (France) and the NE corner near Tongres (Belgium). The information collected for the analysis is in fact wider with an extended buffer-zone of 25 km in all directions (for computationnal reasons).*
- *The map demonstrates clearly the bias induced by the different sizes of communes in France and Belgium. The discontinuity which appears along the border can not be interpreted (at this stage of analysis) as a real change in the level of population growth.*

Convinced by the criticisms which has been adressed to them, the members of EUROSTAT-GISCO decided in 1997 to adress a call for tenders (SUPCOM, GIS Application) to all european researchers specialised in spatial analysis, statistics and cartography, in order to find solutions to this simple question : how is it possible to established correct maps of the European Union derived from the information at Nuts 5 level ?

The *Hypercarte Research Network* which was established as an answer to this call for tender proposed a solution which was considered as interesting by EUROSTAT-GISCO but was finally not selected, because another team proposed an answer to the call for tender which appeared to be better and/or less expensive and/or more related to mainstream reflexion on the MAUP subject. The team which was selected has produced a very interesting report which provide an overview of all existing solutions in the english-american litterature of spatial analysis. But it is clear, at the reading of the report, that they did not succeed in the empirical part of the application and was not able to propose correct solutions for solving problems like the cartography of the variation of population along the France-Belgium borders. The solutions which are proposed are either time- and cost-consuming (reaggregation of data according to spatial autocorrelation level) or non efficient from theoretical and practical points of view (interpolation between centers of territorial units). The main quality (but also the main weakness) of this report is to have focus on *existing methodological solutions (experimentation of all tools available in GIS)* instead of starting from a *conceptual and theoretical reflexion* which can lead (as in the case of the Hypercarte Project) to propose new tools for cartography and spatial analysis *(which are actually not available in GIS).*

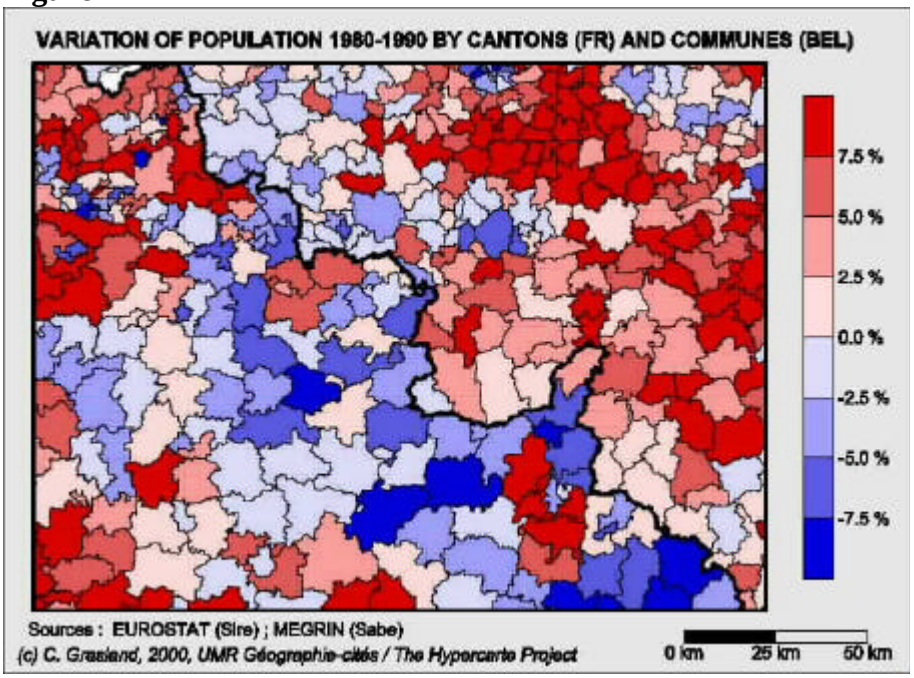
3.2.1.3 THE TERRITORIAL SOLUTIONS OF THE MAUP

Many authors has tried to solve the MAUP by territorial solution which are based on a reaggregation (eventually coupled with disaggregation) of the territorial units in order to obtain a more regular pattern of territorial units according to shape and size. In this framework, two different solutions has been explored,both with advantage and inconvenients:

The mixing of existing territorial levels

When two states are characterised by non compatible territorial divisions, the easiest solution is to use an upper level of aggregation for the state which has the smallest territorial units. In our example, it is obvious that we can obtain a better picture of the variation of population through an aggregation of the french *communes* into the upper level of *cantons* which are more or less compatible in size with the belgium *communes (Figure 2)*

Figure 2



- *The french communes has been aggregated at the upper level of "cantons" or more exactly to "communes or cantons". Indeed, the cantons are a political division which is lower than the commune in urban areas and greater in rural areas. As the information is not available at a level lower than the communes, the urban cantons of the same commune has been agregated.*
- *The picture is certainly more efficient than before in terms of homogeneity of territorial divisions, but we can notice that the french cantons has generally a higher superficy than the belgium communes. Furthermore, the french cantons has a size which vary in urban and rural areas, which is also true but at a less degree in Belgium.*
- *In terms of discontinuities, we can observe an inversion of the gradient along the boundary : growth in Belgium and decrease in France in SE of the study area ; the reverse in the NW part of the area ; no discontinuities in the central part*

This solution is simple - and relatively efficient in the present case - but is not always available. Indeed, it is sometime impossible to find a proper mixture of administrative division which insure the compatibility of territorial divisions in two neighbouring states. Moreover, it can be criticable to use territorial divisions which has different political or economical meaning : even if they are not cartographically compatible the french and belgium commune are comparable in terms of political meaning (*first level of local government*) and it is not obvious that the *Figure 2* is better than the *Figure 1* in all empirical situations. The fact that french communes are smaller than the belgium one is a fact and not only a bias. And this fact has political, social, economical consequences ...

The EUROSTAT Nuts 2 and Nuts 3 level has been criticised by many researchers which prefer the use a combination of Nuts 2 and Nuts 3 levels in order to keep a better homogeneity of surfaces and population. But this solution which can be admit for research purproses is difficult to apply for institutionnal studies related to policy applications at european level (as far as many prims are attributed on those Nuts 2 or Nuts 3 levels ...). In other words, the mixing of level is an unperfect solution which is often impossible for practical, conceptual, political, ... reasons.

The creation of new territorial divisions

Another group of solutions, suggested by many authors is to build new nevels of agregation in order to improve the homogeneity of territorial divisions. The basic idea is to *lose a certain quantity of information (agregation of units) in order to improve the quality (homogeneity) of the resulting information*. Many solutions are available, according to the objective and the constraints which are introduced in the aggregation procedure. Generally, one introduce geometrical constraints (target form and size of the units) and statisticals constraint (minimization of the variancy of the target index inside the agregated units) and use very complex algorithm to find solutions which are not necessary global optimum of the problem to be solved (e.g. simulated annealing).

Conceptually interesting, those solutions has to face to many problems when applied to practical cases. For example, if we do not introduce a political constraint (impossible to aggregate communes from different states in the same cluster) we can obtain crossborder territorial units. This is interesting from scientifical point of view (because it reveals the existence of crossborder homogeneous areas) but it is probably difficult for a political institution like EUROSTAT to produce a map of Europe where political boundaries are removed. Even inside the same state, it is politically very difficult to provide maps where new limits are exhibited and where the usual one are removed.

Moreover, those methods rely on *the overoptismistic assumption that it is possible to define a so-called "optimal level of aggregation"* which could be determined by purely methodological consideration (typically through a combination of estimators of quantity & quality of resulting information).

But if we examine the problem from a theoretical point of view, it appears that the definition of an absolute optimal level of agregation is a nonsense for phenomena related to society and human behaviour. Indeed, the distribution of populations and their attribute are **discrete** and non continuous phenomena. It is to say that an index like the density of population or the variation of population can never be defined (and map) in absolute terms but is necessary related to a particular **scale of analysis**. The choice of the better scale of analysis depend on the question which is asked or the problem to be solved. In each empirical situations, different needs are related to different maps at different levels of aggregation/observation. The classical cartographical solution used in paper atlases ("one variable=one map") appears thus like a profund mistake when applied to social phenomenas.

3.2.1.4 THE MULTISCALAR NEIGHBOURHOOD SOLUTIONS OF THE MAUP

The neighbourhood solutions are more general than the previous one in the sense that they introduce an explicit assumption on the nature (size, shape, scale, ...) of the *geographical filter* to be applied on the phenomena of interest. The idea of geographical filter, which was introduced by W. Tobler's work in the 1960's, rely on the assumption that *a map is not a representation but a construction of reality* which can be made under different

assumptions and for different purproses. In other words, it is impossible to map any phenomenum without defining the aim of the cartographic representation of this phenomenum and (eventually) the internal properties of this phenomenum.

In the case of population variation between 1980-1990, the previous maps by communes or cantons and communes are absolutely correct and interesting as far as we assume that our purprose is to produce a *political-administrative (territorial) representation* of the evolution of the population along the France-Belgium border. For political dirigeants of the communes (or cantons) those maps are certainly the most interesting as far as they permit to identify the evolution of *their own territory*, as compared to the territory of equivalent political-administrative areas. They provide answers to question like : "waht is the evolution of my commune as compare to the evolution of the neighbouring ones ?" or "what is the evolution of my communes as compare to the evolution of the upper administrative level of cantons ?", etc. But of course, they do not answer to *spatial questions* like "what is the mean evolution of population in a neighbourhood of 5, 10, 20 or 50 km (or 1, 2, 3 hours) around the place where my commune is located ?" because those questions rely on other assumptions and require other statistical and cartographical tools to be solved.

The choice of spatial neighbourhoods

If we start from the assumption that population growth is related to physical movements of population which take place in an isotropic and homogeneous space (i.e. if we admit that territorial boundaries are not significant barriers to migration), we can try to propose another picture of population growth where all territorial divisions will be removed. In this case, we can produce a continuum of maps which will reveal the pattern of population growth at different scales of spatial neighbourhood.

The most simple solution is to evaluate the population growth around a given place *i* as the evoluton of population in a circle of radius *R* around this place. But this solution as various disadvantage when we ignore the exact location of population (Cf. Working Paper 1) and it is more suitable to use a continuous spatial interaction function for the definition of the neighbourhood. In this example, we have choosen a gaussian neighbourhood function with parameter R (span of neighbourhood defined as the distance where the value of the function of distance is equal to 0.5). but any other function of neighbourhood could be used accroding to the assumption made on the phenomena.

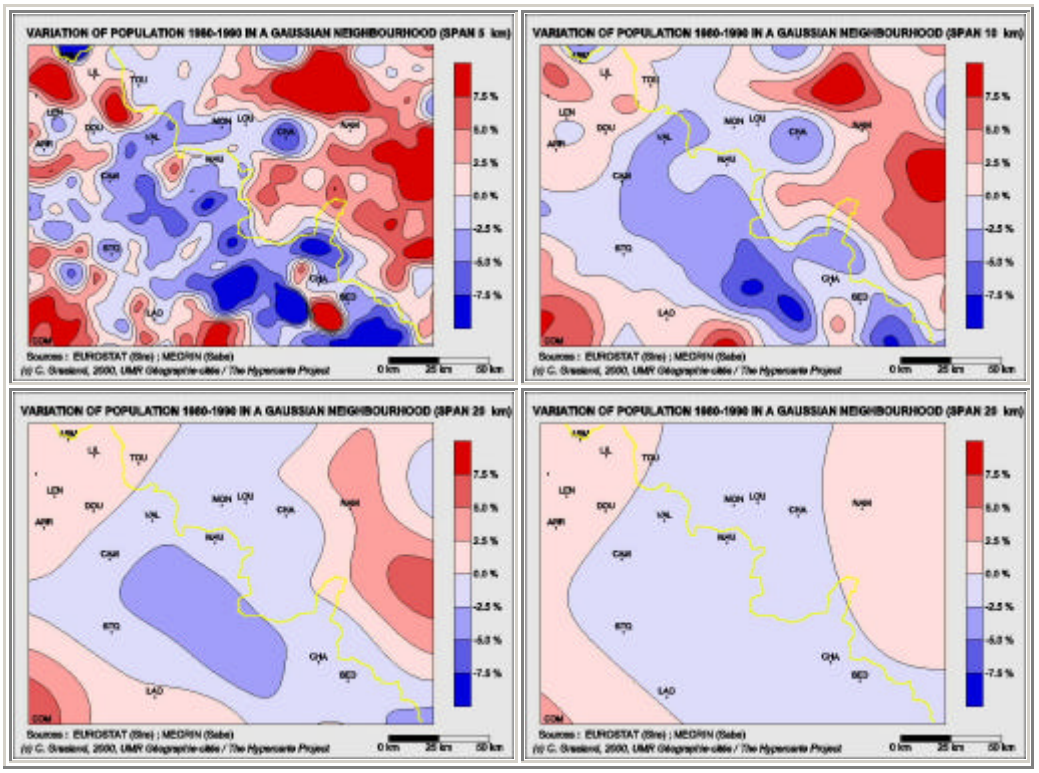
Once we have defined the form of the neighbourhood (here, a gaussian form), we have to determinate the **minimum span of neighbourhood** which insure the elimination of possible bias introduced by the initial level of agregation of the information. This very important question will not be discussed here but we can notice that statistical considerations can be used for the determination of this minimum span of neighbourhood (i.e. span which insure that the bias are lower than 1%, 5% or 10% as compare to the exact surface which could be obtained with full information at maximal level of desagregation). In our example the minimum span of gaussian neighbourhood (for a 95% confidence level) is approximatively equal to 5 km for french communes and 10 km for belgian communes.

When information is not available in a sufficiently wide buffer zone (out of the study area), it is also necessary to define the **maximum span of neighbourhood**, which is related to possible bias introduced by borders effects. In our example, the size of the buffer zone is equal to 25 km. Taking into account the properties of the gaussian function of neighbourhood, we can consider that border effects can introduce bias in the results of all maps where the span of neighbourhood is greater than 10 km. But those bias will affect only the border of the study area and the center of the map will remain correctly estimated as long as it is located at a distance greater from 2 R to the limits of the area where information is available.

Maps of the evolution of population with various span of gaussian neighbourhood

Taking into account the previous considerations, we will propose four representations of the evolution of population 1980-1990 in the France-Belgium area with gaussian neighbourhood of span 5, 10, 20 and 40 km *(Figure 3)*.

Figure 3 : Multiscalar gaussian smoothing methods



- **The variation of population in a gaussian neighbourhood with span 5 km** propose a continuous representation of the variation of population at local level which take into account not only the location of communes but also their relative population. Indeed, if a city with an important decrease of population (on a small area, with high density of population) is surrounded by communes with growing population (on a wide area, with low density of population), the smoothing method will enlarge the area of decreasing population, taking into account the relative population of the city center and its suburbs. In other word, the result is not a simple interpolation between city centers but a real estimation of the decrease/increase of population in the neighbourhood of any place of the observed area. Nevertheless, we have to notice that this map remain biased because the size of belgian communes has a size which is too important for the span of neighbourhood (5km). As a consequence, we can observe a lower number of minima and maxima of population growth in Belgium as compare to France, which is certainly an artefact.
- **The variation of population in a gaussian neighbourhood with span 10 km** is perfectly compatible with maximum and minimum span of neighbourhood and provide a formally unbiased picture of the variation of population in the area of investigation. This map is of course less detailed than the previous one, but the loss in the quantity of information is compensed by a gain in the quality of this information. This map reveals clear regional patterns of growth or decline of population but it is important to keep in mind that what is measure is not the variation of population of singular places (like in territorial approach) but the variation of population *in the neighbourhood of places*. In other word, a commune located in the blue areas of this map is located in a region with declining population but can be locally subject to an increase of the population on its own territory.
- **The variation of population in a gaussian neighbourhood with span 20 km** remain relatively unibiased, even if we have to interpret cautiously the value of the places located at less than 20 km from the border of the study area. For those areas, the gaussian method provide an estimation which is based on an uncomplet neighbourhood under the assumption that the missing values of the neighbourhood has

a mean variation of population equal to the one which is observed in the available neighbourhood. As this assumption can be false, it could be cautious to limit the analysis to the central part of the map (disregarding the 20 km corridors located on the border). The increase of the neighbourhood is related to a simplification of the picture with a reduction of the number of minima and maxima of population growth. This can be regarded as a new information about the trends at a level upper than the previous one. A place can be located in a region of decrease for a span of 10 km but in an area of increase with a span of 20 km. It means that the advantage/inconvenient are different according to the scale of observation.

- **The variation of population in a gaussian neighbourhood with span 40 km** is of course subject to increasing bias related to border effects (see. before) but the estimations proposed by this map remain available in the central part of the study area (out of a corridor of 60 km starting from the limits of the study area). At this scale of analysis, the variation of population appears very homogeneous and no discontinuities (gradients) can be pointed on the France-Belgium borders. On the contrary, we can observe an area of decline which is more or less perpendicular to the direction of the boundary, from Laon to Bruxelles.

3.2.1.5 CONCLUSION

The Modifiable Areal Unit Problem is not only a statistical and methodological question but a fundamental challenge from theoretical and empirical points of views. The lack of efficient solutions to the MAUP problem is probably related to the fact that many authors has tried to solve it in a purely technical way, without considering the theoretical and empirical questions which are involved in the MAUP problem.

- **From a theoretical point of view**, the solution of the MAUP is directly related to a fundamental reflexion on the nature of cartography. Tobler's reflexion remains very accurate from this point of view and it is only through a definite reexamination of the question of cartography (why ? how ? for who ? under which assumptions ?) that solutions can be find to the MAUP challenge. More precisely, the concept of *Hypercarte* (infinite set of possible maps related to the spatial description of a given phenomena) is a way to explore instead of the hypothetic research of an *"optimal solution"* based on statistical considerations derived from information theory. And it appears necessary, in further research, to distinguish clearly between *(a) methods of estimation related to (truly) continuous phenomena* (temperature, altitude, ...) and *(b) methods of estimation related to discrete phenomena where the continuity of the distribution is artificially product by the observer* (most distributions of social phenomenas).
- **From a methodological point of view**, it is now important to proceed to a critical evaluation of existing tools and to specify more precisely their fields of applications both from theoretical and empirical point of view. In many case, statistical or cartographical tools are choosen because they are *available* in the most common-used statistical packages or GIS. This lead to a vicious circle where uncorrect traditional solutions are systematically applied and teached (because they are easily available) and where new innovative solution can not be subject to diffusion (beacause they are not yet implemented in GIS and statistical packages).
- **From an empirical point of view** the agreement to Tobler's theoretical point of view (maps are artificial products realised under certain assumptions for certain purproses) should orient the research in new directions, really adapted to the need of society and actors. As it was demonstrated through the brief example of Mouscron, the cartography of social phenomena can not be based only on statistical consideration but should necessary involve knowledges about social actions (migrations, mobility) and social perceptions (spatial, territorial, network, ...). The choice of a good function of spatial neighbourhood has to take into account statistical consideration (e.g. definition of maximum and minimum span in order to avoid bias) but should also rely on a good knowledge of the question and the phenomenum to be analysed. That is the reason why we consider that *GIS will never produce good maps of social phenomena if they are not build (and use) by people with a complete formation in statisticis AND social sciences*.

3.3 Experiments on the MAUP developed in ESPON 3.1

Author : Claude GRASLAND (November 2004)
Source : ESPON 3.1, Final Report

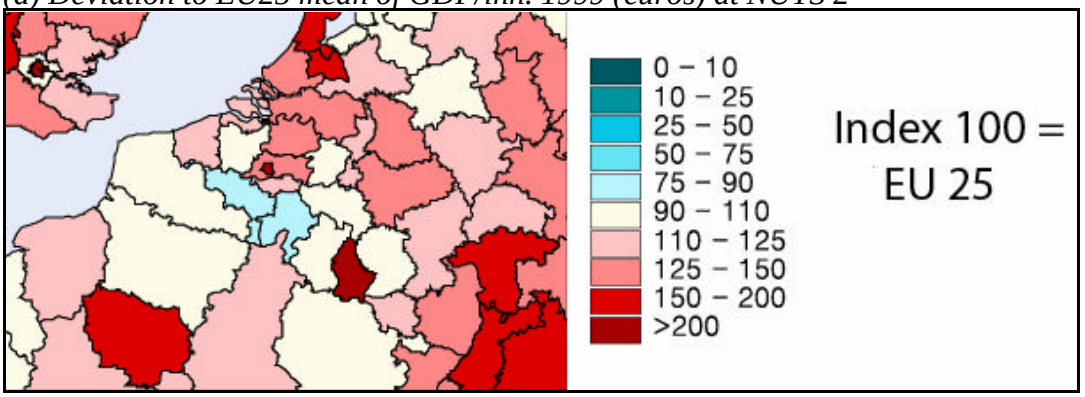
The Modifiable Area Unit Problem which was pointed in the SPESP (1998-1999) remains a crucial challenge for the ESPON 2006 program and was particularly discussed during the Lillehammer meeting in may 2004 in a workshop on polycentrism. It was suggested by P. Mehlbye to explore the question of a possible mixture of NUTS 2 and NUTS 3 levels which could be more accurate from scientific point of view but introduce a political debate as it is no more an official level of elaboration of regional policies. To introduce the debate and provide guidelines for future research on this subject, the TPG ESPON 3.1 has analysed three typical example of existing research developed in he ESPON program and compared the results according to NUTS 2, NUTS 3 and NUTS 2-3 territorial divisions :

- The cartography of regional levels
- The cartography of discontinuities
- The realisation of a typology of regions

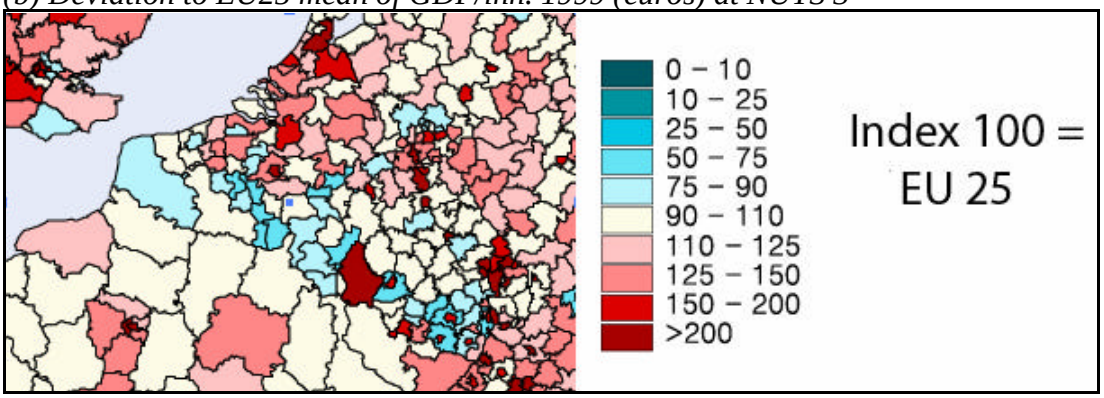
In each case (see. comments on the figures), we have observed very strong modifications of the results when territorial divisions are modified, which means that ESPON faces a real problem and is obliged to introduce an in depth analysis on this subject in the near future. Apparently, the use of a mixture of NUTS 2 and NUTS 3 level is a good compromise between precision of results and elimination of the biases related to the separation of urban, periurban and rural areas. But some problems remain in the case of isolated metropolitan areas at upper scale of territorial division (like Hambourg, Bremen or Brussels-Capital which are NUTS 1 units). Policymakers could agree to the choice of different NUTS level according to the different states (e.g. maps combining NUTS 2 in Germany and NUTS 3 in France) but they would certainly not easily agree to the modification of official NUTS level inside a given state (e.g. aggregation of Brussels with the two regions of North and South Brabant).

Map 1 The influence of NUTS divisions on the definitio n of regional levels

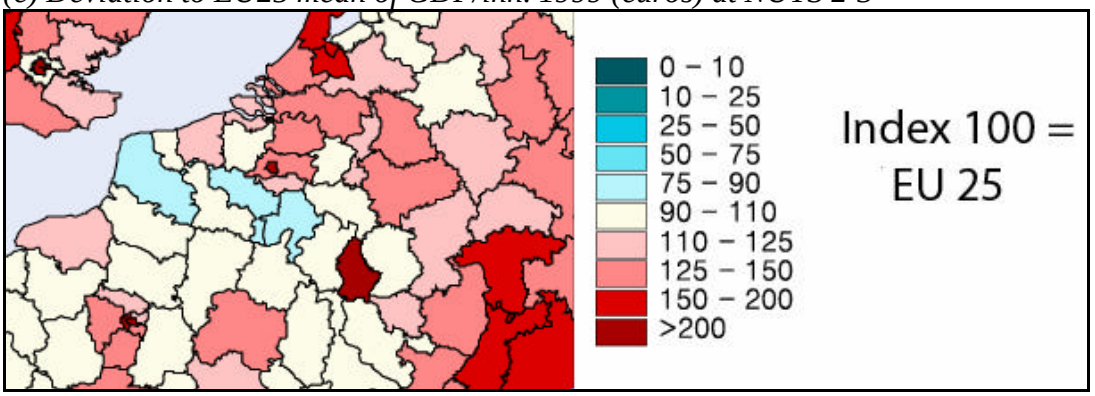
(a) Deviation to EU25 mean of GDP/inh. 1999 (euros) at NUTS 2



(b) Deviation to EU25 mean of GDP/inh. 1999 (euros) at NUTS 3



(c) Deviation to EU25 mean of GDP/inh. 1999 (euros) at NUTS 2-3

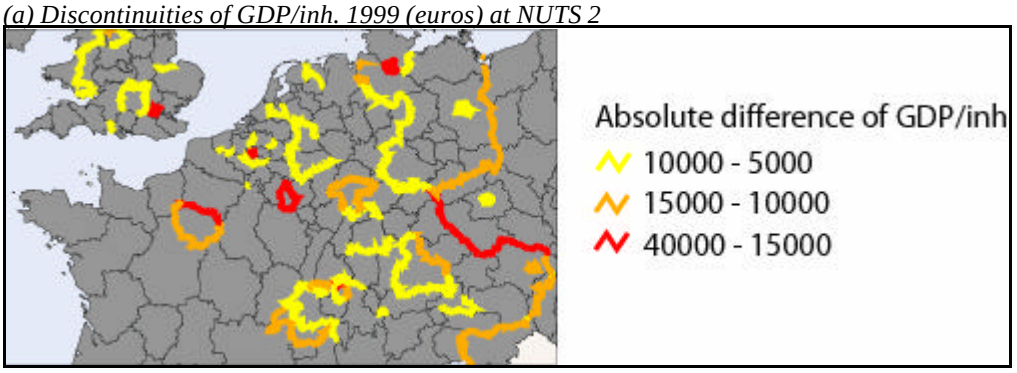


Analysis : The simple definition of regions with high and low level is completely modified by the change of territorial divisions, with huge consequence for the elaboration of policy recommendations

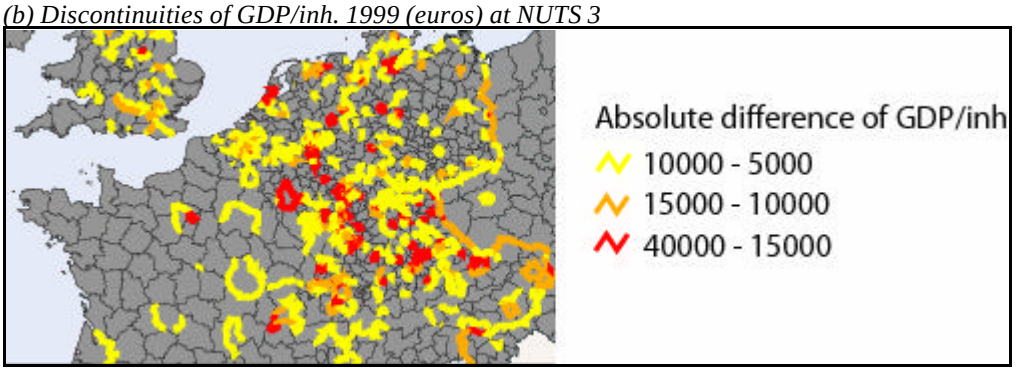
- At nuts 2 levels, only two regions of the sample area located under the mean value of UE25, both located in Belgium. None of them is located under the index 75.
- At Nuts 3 levels, many regions of Belgium, Germany and UK are located under the mean value of UE25 and even under the fatidic threshold of 75, simply because urban, peri-urban and rural areas are separated and because added value which is the base of GDP is allocated to the location of enterprise (located in towns) and not inhabitants (located in all types of area).
- NUTS 2-3 could be a good compromise from scientific point of view. But with deep political consequences for the allocation of structural funds.

Map 2 Influence of NUTS divisions on maps of discontinuities

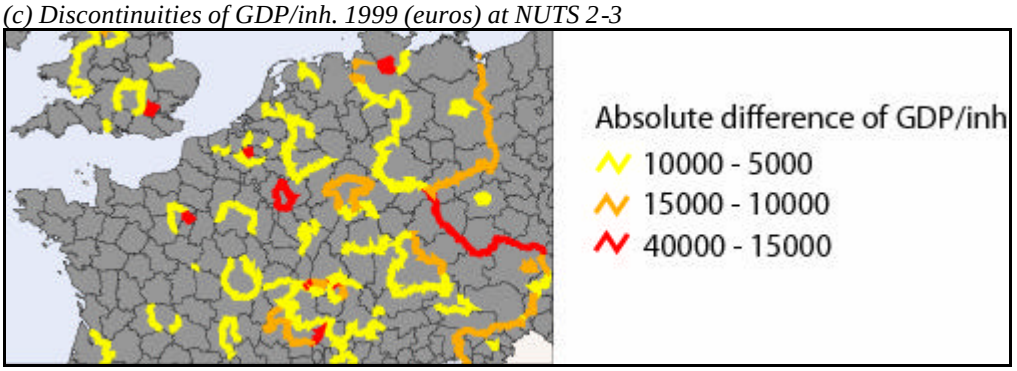
(a) Discontinuities of GDP/inh. 1999 (euros) at NUTS 2



(b) Discontinuities of GDP/inh. 1999 (euros) at NUTS 3



(c) Discontinuities of GDP/inh. 1999 (euros) at NUTS 2-3

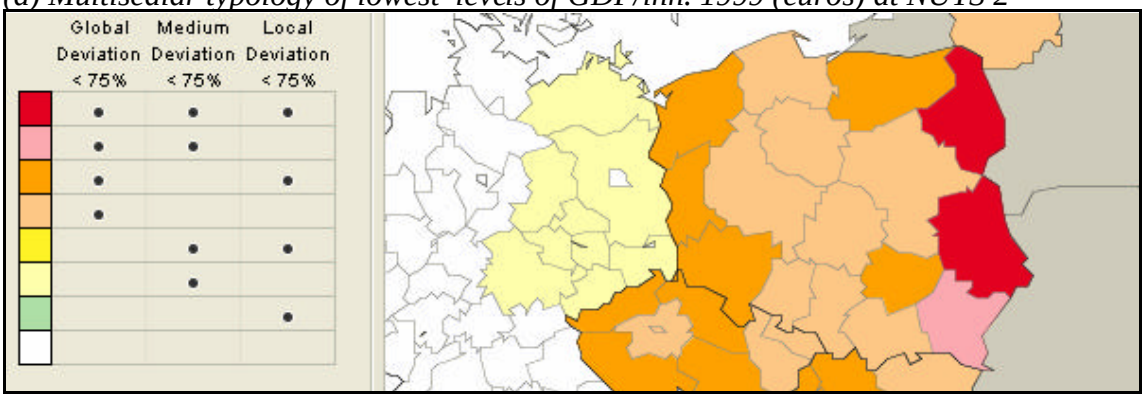


Analysis : The political message delivered by the maps of discontinuities is very different.

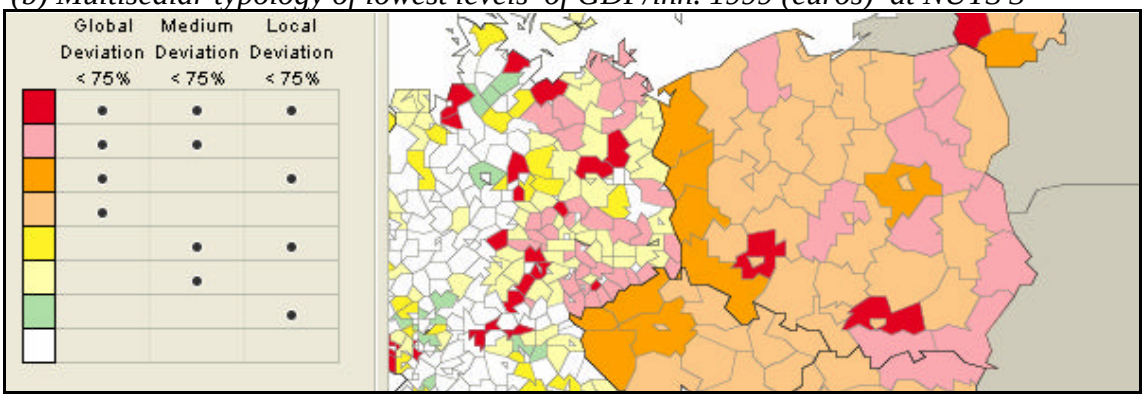
- On the map established at NUTS 2 level, the main message is the relation between the location of main discontinuities of wealth and political or historical borders. Some discontinuities are also related to cities, but only in the case of the main metropolitan regions of each state (Paris, London, Frankfurt, Wien, …). This map give also the feeling that states with smaller territorial divisions (Germany) are more heterogeneous than states with larger regions (France).
- On the map established at NUTS 3 level, the main message is the strong urban-rural opposition, at least in all states where the territorial units are smaller enough to separate urban and rural territories. Germany appears fully covered by discontinuities of GDP/inh which is not the case for France where each NUTS 3 division (department) is still a mixture of urban and rural territories (except in the case of the agglomeration of Paris).
- On the map established at NUTS 2-3 level, a relative homogeneity of size of territorial units is obtained, which provide a more accurate map of discontinuities. But some problems remain for isolated urban areas not associated to their local neighbourhood (Bruxelles, London, Paris, …).

Map 3 Influence of NUTS divisions on the elaboration of regional typologies

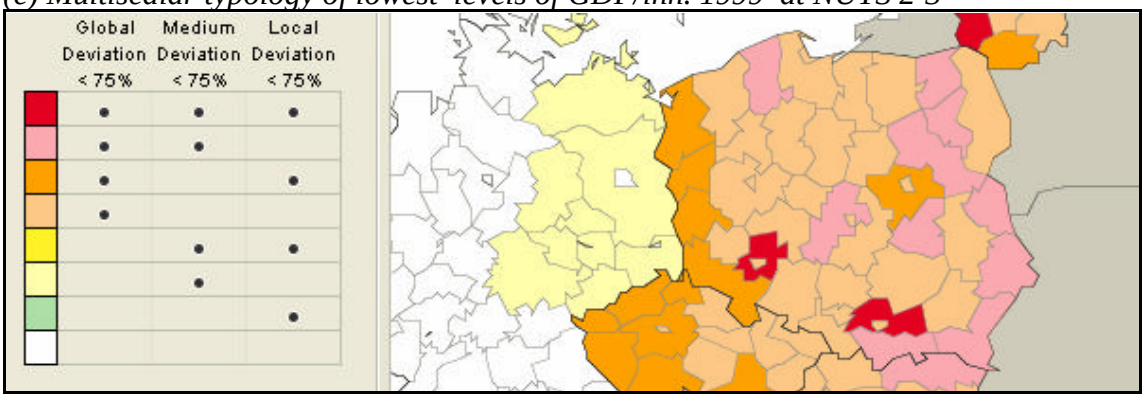
(a) Multiscalar typology of lowest levels of GDP/inh. 1999 (euros) at NUTS 2



(b) Multiscalar typology of lowest levels of GDP/inh. 1999 (euros) at NUTS 3



(c) Multiscalar typology of lowest levels of GDP/inh. 1999 at NUTS 2-3



Analysis : The elaboration of regional typologies, which is a main objective of the ESPON program is very influenced by the choice of territorial breakdowns.

- The typology established at NUTS2 level indicate that only 2 regions of the sample area are considered as "lagging" (<75) at all levels of deviation of GDP/inh. (european, national and local).
- The typology established at NUTS 3 level is completely different with many regions of Germany (not only in eastern part) included now in the red class of "lagging for all criteria of deviation". But more surprisingly, the location of lagging regions of Poland has changed because the table of contiguity (which define the local deviation) is not the same.
- The typology established at NUTS 2-3 level remains criticable from scientific point of view, because of the separation of urban and rual areas in the NUTS 3 regional division of Poland.

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